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CURRICULAR PROBLEMS
IN SCIENCE
at the COLLEGE LEVEL

PALMER O. JOHNSON

COLLEGE PROBLEMS SERIES

THE TEACHING OF SCIENCE
AT THE COLLEGE LEVEL

EDITED BY E. M. FREEMAN
DEAN OF THE COLLEGE OF AGRICULTURE
UNIVERSITY OF MINNESOTA

VOLUME II

CURRICULAR PROBLEMS IN SCIENCE AT THE COLLEGE LEVEL

By

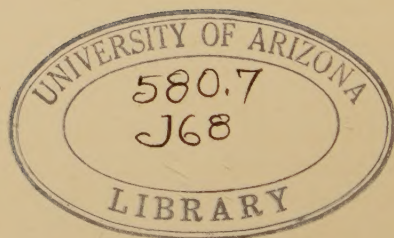
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MINNEAPOLIS
THE UNIVERSITY OF MINNESOTA PRESS
1930

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PREFACE

Plant science, in company with the other sciences, has experienced a tremendous growth since the year 1900. In the century just gone it was commonly thought of as synonymous with botany, but in the present day it has differentiated into many special subsiences while botany has come to denote the field of so-called pure or, perhaps more accurately, unapplied plant science, typically represented in the botanical departments of the "academic" colleges of our large universities.

Nowhere have the plant science offshoots been more numerous or important than in the fields of agriculture and forestry, where plants are under investigation by chemists, horticulturists, agronomists, foresters, soils specialists, pathologists, geneticists, and others, each with his own special technique and each with special scientific objectives or practical applications. It has followed naturally, therefore, that the curricula of agriculture and forestry today contain a bewildering array of special courses in plant science, designed to train scientists in these special fields or practitioners in the arts and industries that have to do with plants. One can find a hundred or more of such courses listed in the catalogue of almost any of our larger agricultural colleges.

It is usually assumed, and with apparent justice, that a fundamental knowledge of plants is essential to a successful study or practice of this great group of applied plant science courses. This knowledge has been provided in most institutions by a course in elementary botany, taught largely from the standpoint of a pure science to college first or second year students. It is probably safe to assume that in most institutions the objective of this elementary course is the teaching of a sufficient amount and a proper kind of basic elementary knowledge of plants to serve either as a general cultural course or as a basis for many or all of the special plant science courses that may follow in or without definite sequence.

Two problems present themselves immediately in the consideration of merely the content matter of such courses in elementary botany. One of these is so obvious as to need no discussion. It is quite clear that the multiplicity of applied sequent courses in the various plant sciences would demand of a single elementary basic course a wide range in sub-

ject matter as well as in methods of treatment. The second problem of content matter is perhaps less obvious and therefore more often disregarded or overlooked. The total subject matter of botany and the applied subsiences has increased enormously in the last quarter of a century. To give the elementary facts in physiology, ecology, anatomy, morphology, and other special fields of plant study has become a difficult task, especially in view of the greater demands that our expanding college curricula have made on the student's time. The teacher of elementary botany is expected to teach much more than he taught formerly in less time than he then had. Can it be done?

It is quite obvious that the amount of material in each section of elementary botanical knowledge must at least be condensed to smaller proportions. When this is done, the question naturally arises as to how effective such a course becomes as a basis or prerequisite for the sequent courses in botany or the applied plant sciences. While it is easy to draw theoretical conclusions as to the probable results, it is more in accord with scientific principles to make a thorough experimental study of the problem. Such a study Dr. Johnson has contributed.

It happens that at the time of Dr. Johnson's study, the course in Elementary Botany at the University of Minnesota had, through some years of gradual and consistent treatment, developed into a standardized course, at least somewhat typical of the elementary botany of many other colleges and universities. The botanical staff in charge of the course had for a number of years consulted frequently with those in charge of sequent courses in the College of Agriculture, and every effort had been made to fit the contents and treatment of the elementary course to the major requirements of the sequent courses. It was the object of all concerned in elementary botany, however, to keep this course general and fundamental and to avoid any attempt to make of it a so-called practical course. Because of the definite organization of material, it was possible to analyze, with at least some degree of satisfaction, the subject matter of the course into definite categories that would permit of comparison with sequent courses. These features of the elementary course in botany, together with an excellent spirit of interest and co-operation among the faculties engaged in the teaching of the various plant science courses throughout the University, provided an inviting opportunity for the study of an important basic college science course in relation to its sequent courses in several fields. Dr. Johnson's experience

in the teaching of science and his intimate knowledge of the courses in the agricultural curricula and of the modern technique of educational research gave an added assurance of an understanding interpretation of the results. It is a matter of comfort, if not of actual satisfaction, to those engaged in the teaching of this elementary course and of the sequent courses, that the demonstrated failure of the elementary course to function successfully as a prerequisite to many sequent courses was inherent in the magnitude and extent of present botanical knowledge rather than in the treatment of the course or the cooperation necessary to success.

Sequent and prerequisite courses are live questions in every college faculty. Prerequisites are prescribed with all of the finality possible in printer's ink. Long sequences of courses are set up by faculties and committees in the sincere belief that one course actually builds upon or continues the work of a prerequisite. That many of such sequences are actually coordinated can be optimistically maintained. That this coordination has been demonstrated by careful and unbiased study is quite another matter. There is little evidence of such studies. It would seem reasonable that here, as also in other phases of science teaching, the scientist who teaches science might properly be expected to throw the cold light of investigation and experimentation on his own teaching methods and requirements.

Do prerequisite courses actually function? Is this sequent course actually built upon the content matter of that prerequisite? Is the assumed sequence predicated on content matter, technique, or other teaching result in the prerequisite? When thinking students affirm that a certain prerequisite is without sequence value, may they not sometimes be voicing a scientific truth that lacks only statistical presentation? Who is responsible for sequence coordination? How great coordination justifies sequence requirements? Why do some prerequisites fail to function? These and many more questions will occur to any college teacher who faces honestly the problem of course sequence. Nor are these questions easy to answer—at least in the manner of science. Opinions are numerous and in positiveness frequently inversely proportional to the investigational evidence available.

It is a matter of some satisfaction, therefore, to have as accurate a study as the one Dr. Johnson has contributed on this important phase of science teaching. While such a study must necessarily deal with the special conditions peculiar to the investigator's materials, it points the

way to the possibility of an analytical experimental study of the subject. It demonstrates that prerequisite science courses need, for their justification, more than a teacher's opinion, unsupported by tangible scientific proof. It also shows that definite and specific causes for the failure of prerequisites to function may be detected and demonstrated. And, as in the solution of many other problems, accurate analysis is usually the first and most necessary step in remedial or corrective treatment.

It is almost inevitable that in studies of this sort educational by-products should appear. Recall of botanical information after varying periods and selective recall in the various categories of botanical subject matter are merely examples of some of these by-products. To the teacher of any plant science the details of analyses of contents of related and sequent courses will offer results of special interest. If Dr. Johnson's contribution does no more than to shake the confidence of college teachers in their unsupported and blind use of the important educational tool of prerequisites, if it even to a modest degree will encourage a more serious and scientific consideration of the possible improvements in the coordination of courses into sequences, it will have served a very useful purpose.

E. M. FREEMAN, *Chairman*
Subcommittee on Teaching of Science

ACKNOWLEDGMENTS

To a marked degree any merit which this investigation may possess is the result of the whole-hearted cooperation of a considerable number of individuals.

To Dr. J. Arthur Harris, Head of the Department of Botany, and to Professor N. L. Huff, in charge of the course in General Botany, the writer is under the deepest obligations for the opportunity of giving the tests and securing data concerning the course. To the other members of the Botany Department and to the heads of the departments and their colleagues in the College of Agriculture and Forestry who furnished syllabi of their respective courses, cooperated in making the analyses, and afforded the time for giving certain tests, sincere gratitude is expressed.

For guidance in developing the plan of the whole study and unlimited generosity in donation of services, invaluable by virtue of profound scholarship in the whole field explored, obligation to Dean E. M. Freeman is inestimable. Neither can adequate recognition be made for the helpful criticisms and counsel given by Dr. Earl Hudelson, chairman, and to the other members of the advisory committee, Dean M. E. Haggerty, Dr. J. A. Harris, Dr. W. S. Miller, and Dr. Leonard V. Koos.

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UNIVERSITY OF MINNESOTA
September, 1929

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CHAPTER I

THE PROBLEM AND ITS SIGNIFICANCE¹

The evaluation of prerequisite courses is the central curricular problem with which the investigations reported in this volume deal. The particular courses chosen for inquiry were those in elementary botany. An evaluation is essayed of the function of these courses in preparing the student for the pursual of sequent courses of a botanical nature in the College of Agriculture, Forestry, and Home Economics of the University of Minnesota.

Certain types of preparation have, perhaps, always been mandatory for admission into any unit of our educational organization. As various curricula have been developed within any given unit, there have been set up prerequisite courses, the completion of which is necessary before certain sequent courses may be pursued. The implication has been that certain abilities must be developed or that certain subject matter or other outcomes of training must be attained by the student in these preparatory courses before he is competent or equipped to undertake advanced courses in a particular field.

It may well be that certain courses, considered as prerequisite to subsequent courses at some time in the past, have perpetuated their status in the curriculum by virtue of this early position rather than because of any propædæutic values which they may now possess.

Elementary botany has nearly always been a required course in the College of Agriculture and Forestry² since the origin of these divisions. As now constituted, the curricular requirements demand nine credits in elementary botany. For a large number of courses the admission is dependent upon the fulfillment of this requirement. Figure 1

¹ An investigation of the literature reveals the fact that the field with which this problem is concerned is apparently unexplored. Certain studies more or less relevant have been reviewed, however, and abstracts are available, together with the tables (see page 6) in the library of the University of Minnesota.

² Hereafter frequent references will be made to the College of Agriculture and the College of Forestry, inasmuch as this study is chiefly concerned with the students in these divisions of the College of Agriculture, Forestry, and Home Economics.

shows how botany is considered basic to courses in the Division of Plant Pathology; Figure 2 does the same for courses in the Division of Horticulture; and Figure 3, for courses in the Division of Agronomy. Is this preparatory training necessary? Is the success with which a student may pursue an advanced course dependent upon how well he has been prepared for it in a prerequisite course? Reciprocally, are these advanced courses organized from the point of view of utilizing to the greatest extent the previous training of the student? These are questions, the answers to which are significant. If elementary botany does not fulfill its obligations as a prerequisite course, then the justification for its incorporation into the curriculum must rest upon modifications that will make this function possible or upon other values that may accrue aside from those as a prerequisite. The justification for any subject in a curriculum must rest upon the outcome of an evaluation of the claims made for it. In the building of a curriculum the articulation of its constituents should be determined. This study is primarily an attempt to determine how well certain values are achieved that would warrant the continuance of elementary botany in the curriculum as a prerequisite to sequent courses in the College of Agriculture and Forestry.

The stages by which the problem was attacked are presented in subsequent chapters:

Chapter II deals with the history of botany courses from the beginning of the University up to the present time. Chapter III is concerned with (1) analyses of the elementary courses in botany and certain sequent courses in the College of Agriculture and Forestry; and (2) an evaluation of previous botanical training in relation to the achievement of students in certain courses in the College of Agriculture. Chapter IV treats of the permanence of learning in elementary botany.

Chapter V, while having a bearing on the central problem, may be considered somewhat subsidiary. Data relative to such matters as the following are presented:

1. Comparison of the achievement of those students who took elementary botany as a required subject with that of those students who elected it.
2. The significance of previous high school preparation in science in relation to achievement in elementary botany.
3. The relation of likes and dislikes of high school subjects to achievement in elementary botany.
4. Sex as a factor in achievement in elementary botany.
5. The relationship of intelligence, as measured by intelligence tests, to achievement in elementary botany.

BOTANY 4			
BOTANY 5			
BOTANY 6 OR ELEMENTARY ECOLOGY 21 OR ELEMENTARY PLANT PHYSIOLOGY 22 OR TAXONOMY OF FLOWERING PLANTS 9			
Forest Pathology 10 or Plant Pathology 1		Weeds and Grasses 7-8	Weeds and Seed Testing 9
Plant Disease Control 14		Seed Problems 12	
Mycology 105-106-107	Methods 108	Principles of Pathology 110	Diseases of Field Crops 111 Diseases of Fruit Crops 112 Diseases of Vegetable Crops 113

FIG. 1.—BOTANY AS A PREREQUISITE TO COURSES IN PLANT PATHOLOGY

BOTANY 4

BOTANY 5

BOTANY 6 OR ELEMENTARY ECOLOGY 21 OR ELEMENTARY PLANT PHYSIOLOGY 22 OR TAXONOMY OF FLOWERING PLANTS 9

Small Fruit Culture 21	Plant Propagation and Nursery Practice 56	Plant Materials 71-72	Orchard Management 107	Pomology 111	Vegetable Production 131-132	Potato Production 135
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FIG. 2.—BOTANY AS A PREREQUISITE TO COURSES IN HORTICULTURE

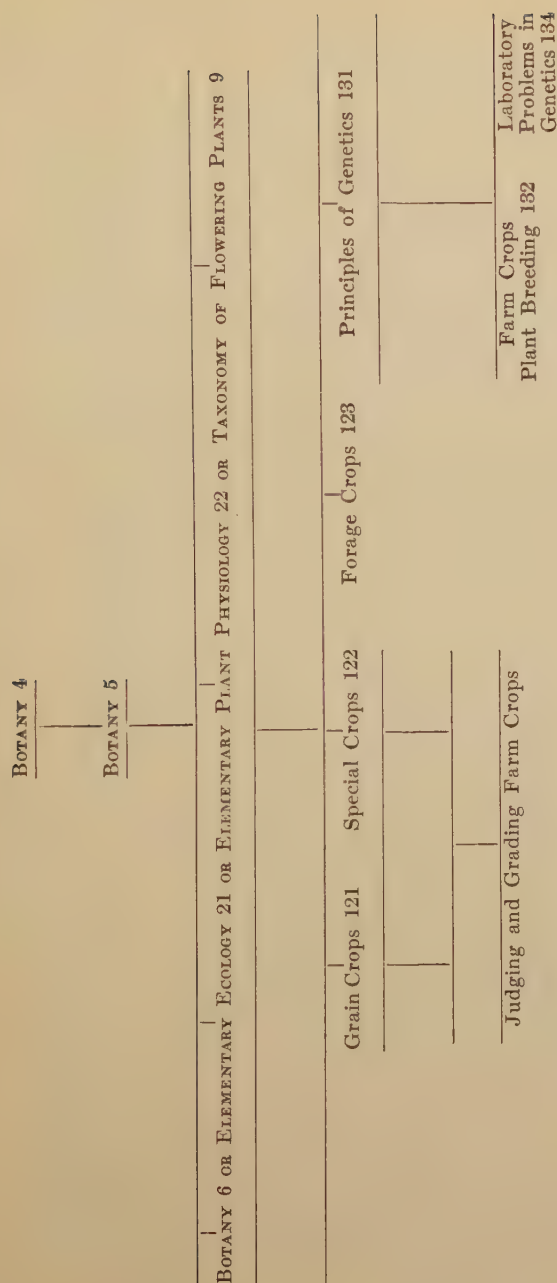


Fig. 3.—BOTANY AS A PREREQUISITE TO COURSES IN AGRONOMY

CHAPTER II

BOTANY COURSES—PAST AND PRESENT

Purpose.—The objective of the study reported in this chapter was to inquire into the changes that have been made from time to time in the courses in botany and determine from the data anything that might be pertinent to the central problem at hand.

Sources and Method.—The materials used were the available publications issued by the University of Minnesota pertaining to its curricular organization, respectively designated as The University of Minnesota Almanac for the years 1871-1873, The Calendar for the years 1874-1886, The Catalogue for the years 1887-1897, and The University of Minnesota Bulletin for the years 1898-1928.

The procedure consisted in surveying the courses in botany offered in the College of Science, Literature, and the Arts, noting more especially the allocation of the elementary course; the time devoted to it; the description given in so far as the limitations of a catalogue permit; whether it was required or elective; as well as the growth of botany as a science, evidenced by the continuous increase in advanced courses. A similar exploration was made in the College of Agriculture and Forestry, noting the changing conceptions with respect to the amount of botany, both elementary and advanced, which entered into the curricular organization.

The Findings.—The data obtained from the study have been summarized in tabular form. Table 1¹ presents data that show the status of botany in the changing organization of the curriculum in the College of Science, Literature, and the Arts as deviations have been made from time to time during the interval 1870-1928.

In the early organization of the University there was designated what was known as the Collegiate Department, necessitated by the fact

¹ Due to the length of certain tables in this study, it was found impracticable to publish them. These unpublished tables are on file in the library of the University of Minnesota, where they may be obtained for reference by those interested. In the discussion that follows, these tables are designated by arabic numbers to distinguish them from those incorporated in the text, which are indicated by roman numerals.

that the public high schools and the Latin schools of the state had not been developed to the extent of fully taking over their preparatory function. The Collegiate Department then received the student from the Latin school or from the public high school and brought him in the course of four years to the end of the second (commonly called the sophomore) year of the ordinary college course. At this point the student had the option of entering, at once, some one of the professional schools then extant or of proceeding with the higher academic studies in the College of Science, Literature, and the Arts. The course of study offered in this college covered a period of two years (junior and senior) and led to the B.A. degree. This propædæutic function was not fully abandoned until 1889.

The course of study in the College of Science, Literature, and the Arts embraced all the secular topics taught to junior and senior classes of the best American colleges. The program was administered in three courses: the scientific, the classical (arts), and the literary (sometimes designated as the modern). From 1899 to 1901 there was recognized a fourth course—the civic. After 1901 the division of the program into special courses was abandoned, being supplanted by group electives, which later gave way to the major and minor systems now in vogue.

In the earlier organization, when the number of courses was limited, the electives were necessarily few. With the increasing number of courses in subsequent years, electives became more numerous but were restricted in a certain sense to special groups, since the additions were largely advanced courses, entrance to which depended upon the completion of certain prerequisite courses.

In the arts and literary courses, botany, sharing two terms' work with analytical chemistry and dynamical physics, was offered as an elective in the senior year during the period 1870-1874. Between 1874 and 1879 botany (equivalent to five credits), consisting of the elements of a structural and systematic type, was required in the classical course during the third term of the subfreshman year (equivalent to the senior year of the high school).

In 1879 one term's work in botany was required in the freshman year in the classical and literary courses, continuing as such until 1892. In addition to the required course, three terms of elective work in physiological botany were offered. Beginning in 1892 and continuing until 1899, a choice between two terms' work (eight credits) in either botany

or zoology was offered. This period witnessed the introduction of eleven advanced courses in botany from which elections might be made by those students with the proper prerequisites. In 1899 the number of courses in the freshman year was expanded so that the student might elect one course from botany (short course); chemistry (short course); physics (long course); zoology (short course); or mathematics. The number of advanced courses from which junior and senior elections might be made had been increased from eleven to thirteen. This arrangement continued until 1901 when, as previously indicated, course designations as such were discontinued.

There seemed to be an early differentiation in the objectives of the elementary courses in botany, depending upon whether they were designed for what might be said to be survey and orientation purposes or for prerequisite purposes—that is, preparation for entrance to advanced courses. This implication is manifest in the development of two types of elementary courses designated as short or long courses according to whether the objective was the one or the other as above indicated. There are latent significances in these data which have considerable bearing on the problem investigated, as will be pointed out later.

The development of these bifurcate courses with differentiating functions may be shown by contrasting the botanical constituents of the scientific course with those of the classical and literary courses as previously reviewed.

In the scientific course, during the period 1870-1874, botany was required for one term in the subfreshman year and divided with physical geography a second term. In addition, botany shared with analytical chemistry and dynamical physics two terms' work as a requirement for the senior year.

Between 1874 and 1879 the requirement in botany was reduced to one term, the same as in the classical course. This apparently did not yield the preparation deemed desirable, so during the interval 1879-1886 botany was required four hours per week in the first term of the sub-freshman year, together with six hours per week in the third term, which was augmented by five hours per week in the third term of the freshman year.

Beginning in 1886 botany was found to be in competition with zoology, with the result that the student in the scientific course was permitted election between the two, depending upon his interest; but which-

ever was elected must be begun in the third term of the freshman year and continued through the three subsequent terms of the sophomore year. This arrangement continued until 1899. It was during this interval that the number of advanced courses in botany had been increased to thirteen undergraduate and seven graduate courses. This is significant in that for most of these courses the four-term course in botany was a prerequisite. In other words, elementary botany had assumed a dual function—exploratory and preparatory.

By 1899 the sciences competing for places in the program of the scientific course had been extended to include chemistry and physics, so that in the freshman and sophomore years one long course (two years) and two short courses (one year each) were required, one of the required short courses being a physical science. That is, in the freshman year a choice of one course had to be made from botany (long or short course), chemistry (long or short course), or zoology (long or short course); and one from botany (short course), chemistry (short course), or zoology (short course). In the sophomore year the long course elected in science was completed and the second short course selected. The electives for the civic course were the same as for the scientific course in the freshman year. In the sophomore year the election lay in a choice of one course from botany (short or long course), chemistry (short or long course), zoology (short or long course), physics (short or long course), or mathematics (Courses IV and V). It is evident, then, that two types of elementary courses existed: the short course, which was primarily of a survey character, and the long course, which in addition carried the preparatory function for the advanced courses. The long course was in almost all cases prerequisite to the advanced courses, which had been increased to fifteen in number.

Beginning with 1901 the differentiation into scientific, literary, and art courses discontinued, as previously indicated, but the basis for election of science courses remained largely the same; that is, those students who elected botany pursued either the short course, consisting of three terms and yielding twelve credits, or the long course, consisting of six terms and granting twenty-four credits. With the introduction of the semester system in 1904, the short course in botany consisted of two semesters (six credits), while the long course continued through four semesters (twelve credits).

In 1907 a change is noted in the elementary courses in botany to

the extent that all students electing it pursued the same beginning course (General Botany 1), which was primarily a survey course consisting of two semesters' work (six credits). However, those students entering the advanced courses continued with General Plant Morphology for two semesters (six credits), thereby fulfilling the prerequisite function. It is thus observed that the dual function of the elementary courses was still recognized; but the survey course in this case was made prerequisite to General Plant Morphology, which in turn became prerequisite to the advanced courses that by 1915 had increased to twenty-nine.

A significant deviation in the status of the elementary courses is again noted in 1915. All students so electing took a course in general botany (General Botany 1a), which had been reduced to a one-semester course of three credits. Differentiation then took place at the beginning of the second semester, when those students who did not continue the study of botany beyond one year chose either a course known as Evolution of Plants (three credits) or Field and Garden Botany (three credits). Those students continuing botany after one year took the course, Structural Botany (three credits), at the beginning of the second semester. Here again is noticed a distinction between the survey and preparatory functions of the elementary courses; but the duration of the survey course for those taking the preparatory course had been reduced one-half from that of the preceding period, and a similar reduction had taken place in the preparatory course itself.

By 1918 all students so electing took two semesters (six credits) of general botany, while those intending to pursue botany further took an additional course (Morphology of Land Plants) for one semester (three credits) as preparation.

With the introduction of the quarter system in 1919, all students electing botany enrolled in a general course consisting of two quarters' work (ten credits) with an additional third quarter of three credits. By this time, then, there was no attempt at differentiation of the elementary courses depending upon subsequent pursuance of botany. In 1920 the third quarter's work was discontinued and we have the elementary course in its present status, consisting of two quarters (ten credits). The course designated as General Botany 4-5-6 required of students in the College of Agriculture and Forestry contains the same materials of instruction as General Botany 1-2 but continues through three quarters and yields nine credits. The advanced courses are twenty-six in number at

present. In the meantime, courses in elementary physiology, elementary ecology, and elementary taxonomy have developed, the significance of which will be discussed later.

THE SIGNIFICANCE OF HIGH SCHOOL PREPARATION

With the discontinuance of the subfreshman year in 1889 (indicating that the secondary schools had been developed to the extent of relieving the University of its preparatory function, but not to the degree of satisfying the University that the function had been adequately fulfilled until an examination on Gray's *Lessons and Manual* had been passed) an examination in botany was required for admission to the scientific course of the College of Science, Literature, and the Arts. In 1896 the admission examination was on the contents of Spalding and Bergen's *Elements of Botany*, which had supplanted Gray's textbook.

In 1899 credit for botany (one year) spent in a study of Spalding and Bergen's *Elements of Botany* or zoology (one year) or physiology (one-half year) and botany or zoology (one-half year) was required for entrance to the scientific course. This specification was abandoned the following year when botany (one-half or one year) was accepted as one-half or one of eight elective credits for entrance to the University. In 1907 botany (one-half or one year) was in a group of electives from which nine credits were selected in addition to the four years of English and two years of mathematics required.

The influence exercised by the University in determining the content is illustrated by the description given of the character of the course to be given in high school botany. In 1899, for example, it was stipulated that Coulter's *Plant Relations* should be used as a textbook and the text should be supplemented during the winter months with morphological work upon the higher plants in their winter conditions and upon preserved material of the lower forms. Such a course was begun in the fall. When one year was devoted to botany, Atkinson's *Elementary Botany* was selected as a textbook and laboratory work in both physiology and anatomy was provided. In all work great emphasis was placed upon the study of plants themselves, but study of the text was required.

By 1904 the textbook to be used was not designated, but schools that gave one-half year of botany were expected to devote particular attention to plant relations, making the course largely ecologic in bearing.

When a whole year was given to the subject, additional work upon plant structures was to be offered and, together with fundamental conceptions of ecology, a general idea of morphology and taxonomy was to be the aim of the course.

Whereas the University was very insistent upon determining the character of high school botany, it apparently did not place much confidence in the functional value of the course. This is shown in that no recognition for the previous preparation of the student, in so far as admission to courses in botany was concerned, was made until 1915, when students with an approved high school course were not required to take General Botany 1a (three credits) but were permitted to enter course 3a (Evolution of Plants) followed by course 2 (Structural Botany) or course 4 (Field and Garden Botany). This concession continued until 1921 when it was discontinued due perhaps to the decreasing numbers who presented botany for entrance (since it had been largely supplanted by biology).² The effect of previous preparation in science, in so far as it is registered in achievement in general botany, is brought out in subsequent data.

Table 2 presents data that show the status of botany in the changing organization of the curriculum in the College of Agriculture and Forestry. In it are found data relevant to the amount of botany, elementary and advanced, required and elective, present in the respective curricula of Agriculture and Forestry, with a brief characterization of the botanical phases emphasized in the elementary courses.

Table I, noting the variations in botany credits (required and elective) in the College of Agriculture and Forestry by periods from 1870-1928, has been prepared for convenience in discussion. Figure 4 illustrates the facts graphically.

The deductions drawn from the data collected with reference to the College of Science, Literature, and the Arts apply largely to the College of Agriculture and Forestry, since throughout the history of its organization the botany courses, required and elective, have been given in the College of Science, Literature, and the Arts and are therefore identical with the courses previously discussed. The only exception might be said to be during the period 1874-1879, when the elementary course offered in the College of Science, Literature, and the Arts was supplemented

² George W. Hunter. "Is There a Sequence in Secondary Science?" *School and Society*, 20:762-766.

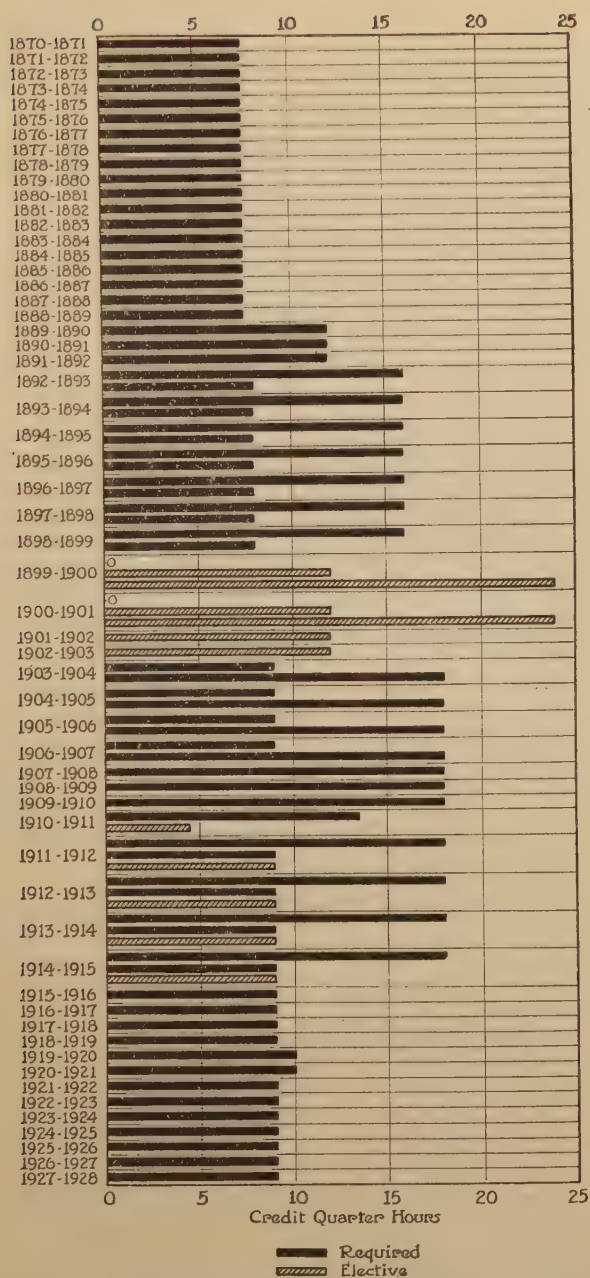


FIG. 4.—DEVIATIONS IN CREDITS (REQUIRED AND ELECTIVE) IN ELEMENTARY BOTANY ENTERING INTO THE CURRICULUM OF THE COLLEGE OF AGRICULTURE DURING THE INTERVAL, 1870-1928

TABLE I

VARIATIONS IN BOTANY CREDITS (REQUIRED AND ELECTIVE) IN THE COLLEGE OF AGRICULTURE AND FORESTRY BY PERIODS, 1870-1928*

Period	ELEMENTARY BOTANY				ADVANCED COURSES IN BOTANY			
	College of Agriculture		College of Forestry		College of Agriculture		College of Forestry	
	Required	Elective	Required	Elective	Required	Elective	Required	Elective
Credit quarter hours								
Total								
1870-1889	7.5							
1889-1892	12.0	7.5						
1892-1893	16 or 8	12.0			8	8	16	16
1893-1899	16 or 8	16 or 8			24	16	24	16
1899-1901		0, 12, or 24				24	24	24
1901-1903		12						
1903-1905	9 or 18	9 or 18				24	24	24
1905-1907	9 or 18	9 or 18			13.5	9	22.5	18
1907-1909	18	18			9		9	6.8
1909-1910	18	18				18	18	6.8
1910-1911	13.5	4.5				18	18	9
1911-1913	18 or 9a	18				18	18	13.5
1913-1914	18 or 9a	9				18	18	13.5
1914-1915	9 or 18b	9c			9b	9b	9b	9
1915-1918	9	9			9c or 18b	9b	9e or 27b	9
1918-1919	9	9			9c or 18b	9c	9 or 18	9
1919-1921	10	10			30e or 10b	10b or 25f	20h or 30i	20 or 30
1921-1923	9	9				25f	or 30g	30i
1923-1926	9	9				10i	10	5
1926-1928	9	9				10i	10	45k'
						3i	3	15i or 50k
								43m
								44.5

* The key to this table is to be found on the opposite page.

by a course in agricultural botany given at the College of Agriculture. Certain highly specialized courses in plant pathology have been given in that department of the College of Agriculture since its organization.

Since the central problem of this study is concerned primarily with the relation of the elementary courses in botany to the College of Agriculture and Forestry and since these courses are given in the College of Science, Literature, and the Arts, the previous discussion is pertinent and these additional deductions warranted.

The College of Agriculture was one of the first departments provided for in the organization of the University, being designated as the College of Agriculture and Mechanic Arts. The course of study extended over a period of two years. The applicants for admission who brought a final certificate from the scientific course of the Collegiate Department of the University were admitted without further examination. Other applicants were required to be at least sixteen years of age and to pass certain examinations (i.e., in all the studies of the scientific course of the Collegiate Department), among which was an examination in the elements of botany. It is observed, therefore, that botany at the time of the organization of the College was a prerequisite in the College of Agriculture and has continued as such with very few exceptions (these also with certain limitations depending upon the specialization of the students) down to the present time.

Beginning in 1870 and continuing until 1889 seven and one-half quarter credits in elementary botany were required of the students in

Key to Table I

^a Animal husbandry students may substitute animal husbandry for advanced botany.

^b Required of students in plant pathology.

^c Elective in agronomy, entomology, and horticulture.

^d Students wishing to specialize may substitute for this course.

^e Required elective in agronomy and horticulture.

^f Students in agricultural biochemistry were expected or it was suggested to include among electives.

^g In agronomy; also in horticulture.

^h In technical forestry.

ⁱ In forest products.

^j Suggested electives in horticulture.

^k Sylviculture group electives.

^l Suggested for course in general forestry.

^m Among the electives for the major in general forestry and forestry sciences.

the College of Agriculture. From 1889 to 1892 the required credits in elementary botany were increased to twelve. In addition eight required and eight elective credits in advanced courses in botany entered into the curriculum.

In 1892 the student was required to take a short or long course in botany and a long or short course in zoology. If he chose the short course in one he took the long course in the other. This continued until 1899. Twenty-four additional credits in botany, at first required, were later changed to elective during this period. By 1899 the student might elect a six-term course (twenty-four credits) in either botany or zoology or a three-term course (twelve credits) in each. This system continued until 1901. The advanced course credits (twenty-four elective) remained the same as in the preceding period, continuing so until 1905. In the interval 1901-1903 the election was botany, four semester credits, zoology, four, or psychology, four, during the first semester; and botany, four, zoology, four, or logic, four, during the second.

There were two factors that entered into this period of election (1899-1903). One was the specialization of the student; the other, the relation of the School of Agriculture to the College of Agriculture. Early provision in the organization of the Department of Agriculture had been made for an elementary course in the School of Agriculture, which in 1874 was mentioned as agreeing in the main with the scientific course of the Collegiate Department (meaning perhaps with respect to preparation for entrance to the College of Agriculture). In the curriculum of the School of Agriculture botany was a required course. With the discontinuance of the Collegiate Department, students were received directly from the high school. The requirements for admission to the College of Agriculture consisted of graduation from the School of Agriculture. Graduates of high schools might be admitted to the freshman class after spending a year in the School of Agriculture pursuing such studies as the faculty might require. Before graduation, however, all the required work in the School of Agriculture must have been completed. Provisions were made, therefore, during the freshman year for two types of students—those with School of Agriculture preparation and those with high school preparation. So there were sections designated as A for students from the School of Agriculture and as B for students from high schools. The work in the College of Agriculture was a continuation of the agricultural studies in the School of

Agriculture, each subject being treated from a more technical standpoint. This relationship existed until about 1909-1910 when the status was reversed—graduates of the School of Agriculture being admitted to the College of Agriculture as special students.

From 1903 to 1907 the requirement was either the long course in zoology and the short course (nine quarter credits) in botany, or the long course in botany (eighteen quarter credits) and the short course in zoology. The required advanced courses (thirteen and one-half quarter credits) and the elective courses (nine credits) made up the additional components of botany in the curriculum.

From 1907 to 1910 all students took the long course in botany (eighteen quarter credits). In addition nine credits in advanced courses were required, from which requirement students in the dairy and animal husbandry courses were relieved from 1909 to 1910. During this interval eighteen additional credits in botany also might be elected.

From 1910 to 1915 the specialization of the student was the factor determining whether nine or eighteen credits in general botany were required. For students majoring in plant pathology nine required credits and nine elective credits in advanced courses in botany were prescribed. Beginning in 1915 and continuing to the present time nine quarter credits of elementary botany have been required of all students. Since 1919 the required advanced courses have been discontinued and the suggested elective courses have been reduced in practically all the departments. The Division of Horticulture alone suggests the election of Elementary Plant Physiology.

In the College of Forestry during the period from 1903 to 1907 nine quarter credits were required in elementary botany. This requirement changed to eighteen in 1907 and remained such until 1911. From that time to the present the number has remained almost constantly nine, the only exception being from 1919 to 1921, when ten credits were required. Additional credits in advanced courses in botany changed from nine, required during the period 1903-1905, to eighteen, elective during the interval 1905-1907. During the period 1907-1910 the number of required quarter credits was six and eight-tenths, which number was increased to nine in 1910-1911, followed by thirteen and five-tenths during the period 1911-1914. From 1914 to 1919 nine credits in advanced courses of botany were required, but this requirement was waived in the case of certain students who wished to specialize. From 1921 to 1923 a five-

credit course in taxonomy was required in addition to the course in general botany. At present Forest Botany (one and one-half credits) is required in addition to general botany. The election of advanced courses depends largely upon the specialization of the student. As many as forty-three credits in botany enter into the sylvicultural group electives.

THE CHANGING CHARACTER OF ELEMENTARY COURSES IN BOTANY

The first elementary course in botany consisted of the study of the elements of structural and systematic botany acquired by the use of a textbook, Gray's *Lessons and Manual*, and hand specimens. Each member of the class was required to analyze correctly and name independently forty or fifty species, keeping full record of the characters and peculiarities of each species. The students of the scientific course who took an additional term's work were given in this a more thorough knowledge of structural and physiological botany and more skill in plant analysis. Economic botany was also taken up. A herbarium of seventy-five specimens was expected of each student. The supplementary course in agricultural botany given to the students at the College of Agriculture dealt with botanical characters, properties, and peculiarities of those natural orders containing plants of interest to the farmer and horticulturist, together with a special study of the most important representatives of these orders.

By 1889 the content of the elementary course in botany had expanded to the extent that it included: one term devoted to the principles of classification, general anatomy of mosses, ferns, and flowering plants; one term to a study of the compositæ and general vegetal histology; one term to further histological study together with lectures upon general physiology and the physiology of nutrition, following the lines of Sachs, Strasburger, and Nageli; and one to the physiology of growth, irritability, reproduction, and special histology of ferns and flowering plants with comparative anatomy, in addition to a brief course of lectures upon evolution and thesis work on the part of the student.

In 1893 the long course—General Plant Morphology—consisted primarily of a study of comparative anatomy and embryology of plants and served to establish the basis of the various special courses in the upper years. The course General Botany 2 presented an outline of special morphology and physiology, with particular emphasis upon

morphology. The latter became a lecture-demonstration course in 1896 and continued as such until 1899.

When the long course in elementary botany was developed in 1899 to include two years, two terms of morphology and one of physiology constituted the first year's work; while the second year included a study of the comparative anatomy and development of plants, together with a study of types extending over the great divisions of the plant kingdom. The student might elect a course in general plant physiology instead of the second year of the long course described above. The short course in elementary botany was identical with the first year of the long course.

In 1901 the short course consisted of a year's study—a general survey of the plant kingdom, including a study of the cell, algæ, lichens, fungi, mosses, ferns, gymnosperms, and flowering plants. The long course was devoted to two years' study of general plant morphology. The first year of this course comprised a thorough laboratory discipline in algæ, fungi, and lichens; the second, a study of mossworts, ferns, and flowering plants. By 1907 the short course in general botany became identical with the first year of the long course, as it had been in 1889.

By 1908 General Botany 1 consisted of a general survey of the field with a laboratory study of the evolution and relationship of plants, greenhouse study of their behavior and structure, as well as field work in the identification and distribution of flowering plants. Advanced Botany 2, for which General Botany 1 was a prerequisite, involved a study of the structure and classification of the great groups of plants based on identification; the details of cell-division, of the formation of tissues, and of reproduction; and the general relations of the plant to the physical factors of its habitat.

In 1915 the first semester of the elementary course consisted of a study of the external form and organs of flowering plants—the root, stem, leaf, fruit, and seed—of their relations to each other, together with simple greenhouse experiments to illustrate the various functions. The second semester of the course comprised a study of the microscopic structure of flowering plants—the cell, tissues, and tissue system, as seen in the root, stem, leaf, etc. In place of the second semester's work, there might be elected a course in the evolution of plants, which consisted of a comparative study of selected types of plants, illustrating the evolution of land plants from the simplest forms. Also, in lieu of the second semester's work, there might be substituted a course in field and garden

botany, which involved a greenhouse, garden, and field study of the form, behavior, nomenclature, and relationship of flowering plants, together with individual problems in the pollination, reproduction, and propagation of common flower types. In 1918 courses designated as General Botany 1-2 and Morphology of Land Plants 5 were identical in content with the first three described above.

Since 1924 the content of the course in general botany has been identical with that of the present course, an analysis of which is presented in the subsequent chapter.

SUMMARY AND SIGNIFICANCE OF THE FINDINGS

Botany has been considered a basic science in the curricula of the College of Agriculture and Forestry since its organization. From a small beginning of seven and one-half quarter credits devoted to elementary botany, the number was gradually increased to twenty-four, then diminished to nine, the number required at present. The median number of quarter credits devoted to elementary botany in the College of Agriculture is twelve for the period 1870-1928. The range in quarter credits of elementary botany required in the College of Forestry for the period 1903-1928 has been from nine to eighteen, with nine the median number. Nine quarter credits constitute the present requirement. In courses of botany other than the elementary, there has been a reduction from a maximum of twenty-four quarter credits as a general requirement to none at present in the College of Agriculture. At the same time the number of elective credits has ranged from three to twenty-four. Since 1914 the specialization of the student has been the basis for election. In courses of botany other than the elementary, the required number of quarter credits in the College of Forestry has ranged from one and five-tenths, a general requirement at present, to thirty in certain specialized courses during the period 1919-1921. In elective courses the range has been from fifteen to forty-five, depending upon the specialization of the student.

As the content of the course in elementary botany expanded concomitantly with the increase of time devoted to it, and likewise contracted with the decrease, the emphasis has been placed from time to time on some particular botanical category. These somewhat distinctive elements are to some degree related to the changes in the administrative heads of the department. Thus, for example, one detects a shift from

systematic to physiological botany or from comparative morphology to morphology of flowering plants. Of course, these changes in emphasis may simply register the changes in the development of the science itself. On the whole, however, as far as a general characterization is possible, due to the limitations of a catalogue or bulletin description, it might be said that the course has remained fairly constant in the nature of its content but variable in comprehensiveness and thoroughness of treatment inasmuch as these may be said to be a function of time.

There gradually developed two types of courses in elementary botany, one of which apparently had the primary function of a survey course; the other, the additional function of a prerequisite. These courses finally merged until at present one course exists, which as far as the organization of the curriculum indicates, is designed to have the twofold function—survey and preparatory. Of the two types of elementary courses, the scope of the survey or short course was a general survey of the plant kingdom with emphasis upon the morphology of flowering plants and comparative morphology; that of the preparatory or long course was similar in nature but more comprehensive and detailed in treatment.

In the development of the curriculum a multiplicity of courses have been added. As illustrative of the enormous expansion of the curriculum, one might compare its present state in the College of Agriculture with the following which constituted the sole program of studies in the junior and senior years in 1875:

JUNIOR YEAR

First Term

Agricultural Chemistry
Agricultural Botany and
Landscape Gardening
History of Civilization
Comparative Philology
or other elective

Second Term

Agricultural Chemistry
Horticulture
Mineralogy or other
elective

Third Term

Agricultural Chemistry
Arboriculture and Eco-
nomic Entomology
Geology or other elective

SENIOR YEAR

Practical Agriculture
(soils and fertilizers)
Comparative Anatomy
and Physiology
History of Philosophy or
other elective

Practical Agriculture
(farm crops)
Veterinary Medicine and
Surgery
Civil Government and
Correlation of the
Sciences or other
elective

Practical Agriculture
(farm animals)
Economics
Political Economy or
other elective

This great expansion in the number of courses, many of which are of a distinctly botanical character, renders the functioning of elementary botany as a prerequisite course more and more difficult, if it is to lay the foundation for these subsequent courses. The question might well be raised whether it is possible for an elementary course of nine quarter credits to function as a prerequisite. For with the increase of content within the science itself, the increase in the number of special courses, the reduction in time devoted to the course itself, together with perhaps a reasonable assumption that it has preserved more the vestiges of its precursors than developed adaptations for the future, it seems fair to assert that the ability of elementary botany to function as a prerequisite in its present state is becoming more and more restricted.

With the expansion of the curricula, the required and elective advanced courses in botany have given way to more specialized courses in the College of Agriculture and Forestry. Together with this expansion, there has resulted specialization on the part of the student. There has been an increase in the number of specialized elementary courses in botany. It might be that these special elementary courses in botany would more nearly satisfy the preparatory function than the elementary course itself.

The subsequent chapter may reveal some of the limitations of the course in elementary botany as a prerequisite when projected into the College of Agriculture and Forestry.

CHAPTER III

ANALYSIS OF ELEMENTARY AND ADVANCED COURSES PERTINENT TO THE STUDY

PROBLEM I

Purpose.—The first investigation reported in this chapter was directed towards a determination of: (1) the botanical constituents of certain courses in the College of Agriculture and Forestry; (2) the botanical constituents of the elementary courses in botany in the College of Science, Literature, and the Arts; and (3) the degree of relationship between (1) and (2).

Sources and Method.—The sources for the data reported here were in the main syllabi which were prepared for this particular problem by the various instructors of the courses represented. In those elementary courses where the content was practically identical with that found in the laboratory manuals, i.e., Elementary Plant Physiology (laboratory) and General Botany 4-5-6 (laboratory), these were used. In General Botany 4-5-6 (lecture), the textbook was the basis of the analysis, since the lectures actually constituted the same content. However, in such a diversity of courses as those analyzed, great variation exists in the form in which the content is available. In the great majority of courses there is not what might be considered a basic text. Reference books and, particularly, government and experiment station bulletins are largely used. In some courses the content is principally limited to laboratory work; in others, to field work. Especially in the advanced courses, the materials of instruction are not restricted to any particular textbook or laboratory manual.

One method of analysis, and perhaps the most objective, might be to survey all the available literature assigned in the various courses, measuring the content found therein by some common unit; i.e., the amount of space devoted to a particular botanical category. This method would be quite inapplicable to those courses made up completely of either laboratory or field work and the amount of space assigned to a particular topic is not always directly proportional to its significance in a particular course. It is a question whether or not the objective in

mind here would warrant an elaborate analysis of this type. At least the time available and the inadequacy of any particular individual's acquaintance with all the material represented would be limiting factors.

The primary object of the analysis was to determine in a general way the nature of the advanced course, particularly with respect to its botanical constituents: that is, whether or not it might be strictly designated as a botanical course and if so to note into what botanical categories the constituents might be classified; then, by a similar analysis of the elementary courses in botany, to detect whether or not the botanical constituents inherent in these courses fell into categories similar to those involved in the advanced courses. The underlying hypothesis is that the more nearly common the categories are to the elementary and advanced courses, the greater might be the expectancy that the former are preparatory to the latter. For example, if algæ are studied in the elementary course but receive no treatment in the advanced courses, the preparatory value of this particular topic might be considered negligible; on the other hand, if cytology is an ingredient of the elementary course and likewise a constituent of an advanced course, the associations built up around the cell in the former course may be drawn upon in subsequent treatment of the cell in the latter. The transfer value is probably a function of the identity of elements, of a conscious recognition of the fact that experience obtained in one connection is applicable to other connections, or of the application of a certain principle of configuration, according as one accepts the theory of transfer of training as respectively enunciated by Thorndike,¹ Judd,² and Koffka.³

An additional factor in evaluating the elementary course in botany, as a prerequisite to the sequent courses, would be the degree to which the botanical elements were retained; more especially, the extent to which those elements were retained, which have a functional value at the time when there is a need for them in the sequent course. This factor of retention and the character of the material retained will be discussed in a subsequent chapter.

¹ Edward L. Thorndike. *Educational Psychology*, II, 353-359. Bureau of Publications, Teachers College, Columbia University.

² Charles H. Judd. *Psychology of Secondary Education*, pp. 421-431. Boston: Ginn & Co. 1927.

³ Kurt Koffka. *Growth of the Mind*, pp. 192-193. New York: Harcourt, Brace & Co. 1925.

The procedure employed in this study (which, while undoubtedly presenting certain limitations, offers a feasible plan of attack) was to secure the cooperation of each instructor, whereby he prepared a syllabus of his course, in which was given the amount of time devoted to each topic treated. Then from a study of the materials of instruction under each topic, the proportionate distribution of the botanical constituents of the topic to certain defined botanical categories was determined.

Any system of classification of the content of botany into botanical categories would necessarily result in some overlapping, but the system adopted attempted to reduce this to a minimum. Of considerable import in the validity of the classification is the fact that the instructors of the various courses analyzed are specialists in their respective fields and their training has been largely in botany. Moreover, botany is an old science, dating back perhaps in its modern sense to Conrad Gessner (1516-1565), who was an acute observer and extensive writer, and who stands as the first naturalist of modern times. This antiquity of the science has materially assisted in the standardization of its nomenclature.

Four main botanical categories, further subdivided into twelve minor rubrics, constituted the system of classification into which the botanical constituents were placed. A fifth major category, non-botanical in character, completed the system of classification.

The categories with their respective definitions are:

I. Morphology

1. *Morphology of flowering plants.*—The study of the gross structure of one or more typical flowering plants; involves a general knowledge of the essential parts of flowering plants; detailed and microscopic studies of parts are only incidentally included; systematic microscopic studies are under histology and cytology. Gross studies are associated with explanations in terms of functions.
2. *Comparative morphology.*—An intimate study of the morphology of plants or plant groups in comparison with other plants or plant groups to determine the evidence (macroscopic and microscopic) of the natural relations existing between such plants or plant groups.
3. *Histology.*—A detailed, usually microscopic, study of the structure of plants; chiefly a study of tissue elements and tissue systems; studies usually associated with the functions of tissue elements and tissue systems, as well as elements in physical characteristics affecting natural and applied uses.
4. *Cytology.*—A detailed study of the structure and function of plant cells

and the essential constituents of the cell together with their behavior in the various phases of the life of the cell.

II. Physiology and Ecology

5. *Physiology*.—The study of functions in plants; the study of plant behavior as a whole, and of individual parts; includes biological, physical, and chemical studies.
6. *Ecology*.—The study of plant behavior in its relation to habitat and environment (includes geology and mineralogy as applied to plants).
7. *Plant pathology*.—The study of plant diseases; includes the study of abnormal functioning and of morphological variations of the host; the morphological and physiological studies of pathogenes; abnormal functioning due to environmental non-pathogenic causes and remedial measures or measures of control.

III. Taxonomy.—The study of the classification of plants.

8. *Taxonomy of flowering plants*.—The taxonomy of the spermatophytes.
9. *Algology*.—Primarily a taxonomic study of algæ but includes morphological and physiological studies.
10. *Mycology*.—Primarily a taxonomic study of fungi but includes morphological and physiological studies.
11. *Bacteriology*.—Primarily a taxonomic study of bacteria but includes morphological and physiological studies.

IV. Genetics

12. *Genetics*.—The study of biological inheritance and its physical basis; includes studies of control and application in plant breeding.

V. Non-botanical phases

Anything strictly of a non-botanical character, i.e., economics, woodwork technique, geography, surveying, mathematics, physics, or such material inherent in a course of study not concerned with the botanical phases enumerated above.

In most cases the content of the syllabus of a particular course was analyzed by the investigator in conference with the instructor who had prepared it or in conjunction with an authority in the field, and then submitted to the instructor for correction or approval. In one case the teaching committee of the division furnished the analysis.

ILLUSTRATIONS OF TECHNIQUE

By way of illustrating the technique employed in the division of the botanical constituents of a topic of a particular course into botanical categories, two illustrations will be cited:

I. Course: Vegetable Growing, Horticulture 32 (laboratory)

1. Topic: control of insects and diseases

2. Time devoted to topic: one laboratory period
3. Constituents of topic
 - A. Vegetable crop insects
 - B. Diseases of vegetable crops
4. Proportions of division of period
 - A. Botanical—one-half
 - B. Non-botanical—one-half
5. Character of botanical constituents
 - A. Classification of vegetable crop diseases based upon cause or causes of the disease or diseases
 - a. Bacterial diseases
 - aa. Bacterial blight of the bean
 - bb. Black rot of cabbage
 - cc. Angular leaf-spot of cucurbits
 - dd. Black leg of potato, etc.
 - b. Slime mold (*Myxomycetes*) diseases
 - aa. Club root of cabbage
 - bb. Powdery scab of potatoes
 - c. Fungous diseases
 - aa. Asparagus rust
 - bb. Anthracnose of the bean
 - cc. Late blight of potato
 - dd. *Fusarium* wilt of tomato, etc.
 - d. Virus diseases
 - aa. Mosaic diseases
 - e. Physiological diseases
 - B. Description of typical vegetable crop diseases
 - a. Hosts
 - b. Economic importance
 - c. Symptomatology
 - d. Etiology
 - aa. Life history of causal organism
 - bb. Type of inoculum
 - cc. Agents of transmission
 - dd. Conditions favoring inoculation and development of organism
 - ee. Critical period from the standpoint of control
 - e. Control measures
 - f. Botanical classification
 - aa. Family
 - bb. Common name
 - cc. Genus
 - dd. Species and variety
 - ee. Locality

From an analysis of the botanical constituents of this topic it is observed that by definition they would fall into the botanical category, plant pathology. Since half of the period was devoted to insects and the other half to vegetable crop diseases that would come under the category, plant pathology, the proportionate division of the period would be plant pathology, 50 per cent, and non-botanical, 50 per cent.

II. Course: Grain Crops (Agronomy 121)

1. Topic: barley study
2. Time devoted to topic: four hours
3. Constituents of topic
 - A. External morphology of barley spikes and grain classification
 - B. Cultural practices and economic importance
4. Proportions of division of time
 - A. Botanical, two and two-thirds hours
 - B. Non-botanical, one and one-third hours
5. Character of botanical constituents
6. Classification of barley
 - A. *Gramineæ Hordeum*
 - a. *Spontaneum*
 - aa. Wild barley
 - b. *Vulgare*
 - aa. Six-row, all spikelets awned or hooded and of nearly same size
 - c. *Intermedium*
 - aa. Six-row, lateral spikelets reduced in size and bear neither awns nor hoods
 - d. *Distichon*
 - aa. Only central spikelet is fertile, lateral spikelets contain flower parts but are non-functional
 - e. *Deficiens*
 - aa. Lateral spikelets very small and possess no rudimentary sexual organs

7. Procedure

- A. Carefully study the barley spikes furnished and determine the proper place in the classification for each variety. List the variety names and follow each by the correct name of species as determined by the study
- B. Using Extension Folders 18 and 19, make an accurate study of the recommended varieties. Describe each Minnesota grown variety as follows:
 - a. Name—varietal and species
 - b. Two-row or six-row
 - c. Origin

- d. Desirable characteristics
- e. Undesirable characteristics
- f. Remarks: points that may help in identification of variety
- C. Study of threshed samples of barley
 - a. How can differentiation between two-row and six-row barley-threshed grain be made?
- D. Questions
 - a. Which species makes up the greater part of our cultivated barleys?
 - b. Which is least important?
 - c. How did Velvet barley originate?
What are the advantages of this barley?
 - d. What is the chief advantage of Minsturdi?
 - e. Why is Trebi not included on the recommended list?
 - f. What can be said regarding the yielding ability of the hooded barleys?
 - g. Give rate of seeding barley
 - h. What is considered a good yield?
 - i. What use is made of the barley crop?

As nearly as can be determined from an analysis of this topic, the botanical constituents would come under the categories, taxonomy of flowering plants and morphology of flowering plants, in about equal proportions, since a study of the external characteristics of barley forms the basis for classification. Fully a third of the topic is devoted to strictly agronomic features and would therefore fall into the non-botanical category. The amount of time given to the treatment of this topic is four hours, so the distribution of these would be approximately one and one-third hours to morphology of flowering plants, one and one-third hours to taxonomy of flowering plants, and one and one-third hours to the non-botanical category.

Notwithstanding the limitations placed upon the technique of analysis employed, the assumption seems warranted that the botanical constituents of a given course have been classified with a reasonable degree of certainty into the various botanical categories forming the basis of the system of classification.

Findings.—The data from the analyses of the elementary courses in botany and sequent courses in the College of Agriculture and Forestry have been prepared in tabular form.⁴

⁴ See footnote, p. 6. Tables 3 to 29, inclusive, which are mentioned in the following discussion consist of the content of the respective courses discussed. The time devoted to each topic is given and the proportion of time given to the

ELEMENTARY BOTANY COURSES

Table 3 gives the results of the analysis of General Botany 4-5-6 (lecture⁵) while Table 4 gives the results of the analysis of General Botany 4-5-6 (laboratory). This is a nine-credit course consisting of two laboratory periods and one lecture period per week for three quarters. It is a required course for all students in the College of Agriculture and Forestry. For the third quarter's work, i.e., General Botany 6, there may be substituted any one of the elementary courses: Taxonomy of Flowering Plants 9, Elementary Plant Physiology 22, or Elementary Ecology 21. General Botany 4-5-6 contains the same materials of instruction as General Botany 1-2, which is given to the students of the College of Science, Literature, and the Arts. Table 5 gives the time in hours allotted to the different topics comprising the content of General Botany 1-2. With the exception of an additional quiz section period per week given to General Botany 1-2, the time distribution to it and to Botany 4-5-6 is practically identical.

The basis of determining the distribution of botanical constituents in the several botanical categories in General Botany 4-5-6, while differing to the extent of taking the number of pages in the text and the proportionate part of the laboratory exercises rather than the proportion of the lecture or laboratory period devoted to each category (as was done in the analysis of other courses), is in this case quite identical to the other basis, since the correlation between the two is very high. This is shown by the fact that as one laboratory period is given to the topic, "The Flowering Plant," so is one exercise in the laboratory manual given to it, and just as four laboratory periods (eight hours) are given to the topic, "The Seed and Its Germination," so are four laboratory exercises in the laboratory manual given to the same topic, etc. There is a slight difference in the case of the topic, "The Cell," where three laboratory periods (six hours) are given to it, but only two laboratory exercises. On the whole, however, the relationship between the two bases of analysis is very high. The reason for using a slightly different basis of analysis was that in this course, as previously mentioned, all

several botanical categories and the non-botanical category is shown. A summary of the results from each table is given with the discussion of each course concerned. A composite of all these analyses is presented in Table II.

⁵ Based upon the textbook analysis of Holman and Robbins' *Textbook of General Botany*. New York: John Wiley & Sons, Inc. 1924.

the content is practically represented in the textbook and laboratory manual. Where this is true, the analysis on the basis of allotted space to a particular category probably represents a more accurate type than that where the analysis is made on the basis of time devoted to a particular category. The same argument holds for the analysis of elementary physiology (laboratory).

The percentages of space devoted to the several botanical categories in General Botany 4-5-6 are:

	Morph. Comp.				Phys.-						
	Fl. Pl.	Morph.	Hist.	Cyt.	Phys.	Ecol.	Ecol.	Alg.	Myc.	Bact.	Genet.
Lecture	17	20	15	5	12	6	....	9	9	3	4
Laboratory	19	19	18	3	....	....	21	9	9	2	....

These percentages reveal a very close relationship between the lecture and the laboratory work. Since General Botany 4-5-6 has a very significant bearing on the central problem under discussion in this study, the outcome of the analysis as discussed above will be frequently referred to in the subsequent discussion of the analyses of the sequent courses.

Table 6 shows the distribution of the content of Elementary Ecology 21 (lecture) and Table 7 of Elementary Ecology 21 (laboratory) in the various botanical categories. These distributions in per cent are:

	Hist.	Phys.	Ecol.	Myc.	Bact.
Lecture	6	27	65	.5	1.5
Laboratory	34	13	53	....	....

Elementary Ecology 21 is a three-credit, one-quarter, introductory course in the study of plants in relation to their environment.

The results of the analyses of Elementary Plant Physiology 22 (lecture) and Elementary Plant Physiology 22 (laboratory) are given in Tables 8 and 9, respectively. The distribution of content in per cent is:

	Hist.	Phys.	Ecol.	Cyt.	Bact.
Lecture .....	....	90	10	....	....
Laboratory	6	73	16	2	3

This is a three-credit, one-quarter, introductory course, giving a general survey of plant functions.

Taxonomy of Flowering Plants 9 is a three-credit, one-quarter course, involving a general study of the classification and relationships of flowering plants. The content in per cent is:

Morph.			Tax.
Fl. Pl.	Hist.	Ecol.	Fl. Pl.
35	1	3	61

COURSES IN PLANT PATHOLOGY AND BOTANY

Table 10 shows the proportion of class periods devoted to the several botanical categories in Plant Pathology 1. Plant Pathology 1 is a five-credit, one-quarter course, open to juniors and seniors who have had nine credits of botany. The botanical content of this course is divided into five categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.		Hist.	Cyt.	Phys.-		Alg.	Myc.	Bact.	Genet.
	Fl. Pl.	Morph.			Ecol.	Ecol.				
Botany 4-5-6	18	19.5	16.5	4	19.5	9	9	2.5	2	
Plant Pathology 1 ....	....	.....	19.0	....	19.0	....	30	7.0	1	

If botany were being taught to prepare a student for work in plant pathology a greater emphasis than now exists would be placed upon mycology and bacteriology. In fact, this is the only advanced course that emphasizes mycology. This is to be expected, since it deals primarily with plant diseases due to fungi, bacteria, and slime molds.

Table 11 gives the proportion of class periods devoted to the several botanical categories in Weeds and Grasses 7-8. This is a six-credit course, two quarters in length, open to sophomores, juniors, and seniors who have had nine credits in botany. The botanical content of this course is divided into four categories and contrasted with the distribution (in per cent) of the content in General Botany 4-5-6 as follows:

	Morph. Comp.		Hist.	Cyt.	Phys.	Ecol.	Phys.-		Alg.	Myc.	Bact.	Genet.
	Fl. Pl.	Morph.					Ecol.	Fl. Pl.				
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	9	9	2.5	2
Weeds and Grasses 7-8	32	.....	.....	....	16	8	.....	26	....	....	....	....

The significant deficiencies in the course in elementary botany from the standpoint of functioning as a prerequisite for Weeds and Grasses would appear to be the dearth of treatment given to plant relationships and too little emphasis upon morphology of flowering plants, for this particular course is predominately a taxonomic study of weeds and grasses.

Table 12 shows the proportions of class periods devoted to the several botanical categories in Weeds and Seed Testing 9. This is a three-credit, one-quarter course, open to sophomores, juniors, and seniors who have fulfilled the prerequisite requirement of nine credits in botany. Since in this course weed and crop seeds and weed plants are studied with special reference to identification, one would anticipate the distribu-

tion (in per cent) of the content which, contrasted with General Botany 4-5-6, is as follows:

	Morph. Comp.			Cyt.	Phys.	Ecol.	Phys.- Tax.			Myc.	Bact.	Genet.
	Fl. Pl.	Morph.	Hist.				Ecol.	Fl. Pl.	Alg.			
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	9	9	2.5	2
Weeds and Seed Testing 9	42	.....	.....	....	11	5	.....	15	....	....	.....	....

Not all parts of plants are emphasized in this course, but mainly those that have to do with the development and maturation of good, viable seed. It is desirable, therefore, that the student be familiar with the structure of fruits and seeds and their modifications. Also a functional knowledge of the physiology of plant growth, dormancy, and renewal might very well be stressed in preparation. More training in morphology of flowering plants than that given in elementary botany and at least some instruction in plant relationship might enhance the value of elementary botany as a prerequisite for the course in Weeds and Seed Testing.

COURSES IN HORTICULTURE

Table 13 shows the proportions of class periods devoted to the several botanical categories in Vegetable Growing 32 (lecture), while Table 14 does the same for Vegetable Growing 32 (laboratory). This is a three-credit, one-quarter course, consisting of two lecture periods and one laboratory period per week. The distribution of the botanical content (in per cent), contrasted with that of General Botany 4-5-6, is as follows:

	Morph. Comp.			Cyt.	Phys.	Ecol.	Phys.- Pl. Tax.			Myc.	Bact.	Genet.
	Fl. Pl.	Morph.	Hist.				Ecol.	Path.	Fl. Pl.	Alg.		
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	....	9	9	2.5
Vegetable Growing 32												
Lect.	15	.....	.....	....	24	13	.....	4	7	....	....	10
Lab.	6	.....	6	....	26	13	.....	7	9	....	2	12

The greater emphasis in this course is placed upon physiology. With the exception of this emphasis on physiology and some content in the categories of taxonomy, genetics, and plant pathology, the relative attention to other botanical categories is quite comparable to that given them in elementary botany.

Table 15 gives the distribution of the content of Fruit Growing 6 to the several categories. The botanical content of this course is divided

into seven categories and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.				
	Fl. Pl.	Morph.	Hist.	Cyt.	Phys.	Ecol.	Ecol.	Path.	Fl. Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	....	9	9	2.5	2
Fruit Growing 6	20	.....	.....	1	30	15	.....	2	6	....	....	.....	3

With the exception of genetics, to which less attention is given, and morphology and physiology, to which slightly more attention is given, the distribution is very similar to that of Vegetable Growing 32. This is quite logical since the one course is primarily a study of the fundamental principles of vegetable growing; the other, a similar study of fruit growing. Fruit Growing 6 is also a three-credit, one-quarter course consisting of two lecture periods and one laboratory period per week. Either Fruit Growing 6 or Vegetable Growing 32 is required of all students in the College of Agriculture.

Table 16 gives the results of the analysis of Small Fruit Culture 21. This is a one-quarter, three-credit course, open to sophomores, juniors, and seniors who have had nine credits of elementary botany and the course in Fruit Growing 6 or Vegetable Growing 32. The botanical content of this course is divided into five categories and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecol.	Ecol.	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18		19.5	16.5	4	....	....	19.5	....	....		9	9	2.5	2
Small Fruit															
Culture 21	9		.....	.....	....	21	28	.....	2	9	....	....	.....	....	

It is seen that physiology, ecology, and taxonomy of flowering plants receive considerably more emphasis in this course than is given them in the course in elementary botany. Since either Fruit Growing 6 or Vegetable Growing 32 is also a prerequisite, either may serve to add to the previous preparation of the student in botany.

Table 17 shows that the botanical constituents of Systematic Pomology 111 may be classified into two botanical categories and are contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.				Phys.-		Tax.			
	Fl.Pl.	Morph.	Hist.	Cyt.	Ecol.	Fl.Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	19.5	....	9	9	2.5	2
Systematic Pomology										
111	28	.....	.....	....	.....	68	....	....	.....	....

This is a three-credit, one-quarter course, open to juniors and seniors who have had nine credits in elementary botany and Fruit Growing 6. The most marked deficiency in the preparatory value of elementary botany to this course would apparently be the absence of the treatment of plant relationships, since Systematic Pomology 111 deals predominantly with the classification, description, and identification of fruit varieties. Fruit Growing 6 may partly make up the deficiency, since 6 per cent of its botanical constituents deals with plant relationships of fruit varieties.

Table 18 gives the analysis of Potato Production 135. This is a three-credit, one-quarter course, open to juniors and seniors who have the prerequisite requirements—nine credits in elementary botany and either Fruit Growing 6 or Vegetable Growing 32. The botanical content of this course is divided into six categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecol.	Ecol.	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	----	----	----	19.5	----	----	9	9	2.5	2	
Potato Pro- duction 135	8	-----	-----	----	17	19	-----	8	6	----	----	-----		8	

This course emphasizes physiology and ecology, and, to a lesser extent, taxonomy and genetics.

COURSES IN AGRONOMY

Table 19 gives the proportions of class periods devoted to the several botanical categories in Farm Crops 1. This is a three-credit, one-quarter course, required of all students in the College of Agriculture. The botanical content of this course is divided into seven categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.				Phys.-			Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecol.	Ecol.	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany	4-5-6	18	19.5	16.5	4	....	....	19.5	....	....		9	9	2.5	2
Farm															
Crops	1	....	25	.....	....	10	6	.....	4	15	....	....	1.0	1	

The significant difference between the phases of botany involved in it and those entering into elementary botany is the 15 per cent of time devoted to taxonomy of flowering plants. General Botany 4-5-6 is not a prerequisite to it; but ordinarily a considerable number of the students enrolled have had the course in elementary botany.

Table 20 gives the analysis of Grain Crops 121. This is a three-credit, one-quarter course, open to juniors and seniors who have had Farm Crops 1 and nine credits in elementary botany. The botanical content of this course is divided into six categories and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecology	Ecology	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	....	9	9	2.5	2		
Grain Crops															
121	21	.....	.....	....	5	9	.....	1	18	....	....	....	....	....	8

A limitation of the preparatory value of elementary botany for this course might lie in the fact that, whereas General Botany 4-5-6 does not emphasize taxonomy of flowering plants, this particular category receives an allotment of 18 per cent in Grain Crops. It may be that Farm Crops 1 assists considerably in preparing for this course.

Table 21 shows the analysis of Corn and Potato Crops 122. The botanical content of this course is divided into six categories and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecology	Ecology	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	....	....	19.5	....	....	9	9	2.5	2		
Corn and Pot.															
Crops 122	19	.....	.....	....	11	16	.....	2	4	....	....	....	....	....	7

This is a three-credit, one-quarter course, with the same prerequisites as those mentioned for Grain Crops 121. If elementary botany gave more emphasis to ecology and some attention to taxonomy of flowering plants its preparatory value for this particular course might be increased.

Table 22 gives the analysis of Forage Crops 123. This is a three-credit, one-quarter course, open to juniors and seniors who have had nine credits in elementary botany and the course in Farm Crops 1. The botanical content of this course is divided into six categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.					Phys.-		Pl.	Tax.						
	Fl.	Pl.	Morph.	Hist.	Cyt.	Phys.	Ecology	Ecology	Path.	Fl.	Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18		19.5	16.5	4	....	....	19.5 ^p	....	....		9	9	2.5	2
Forage Crops															
128	6	.....	.....	....	5	17	9	3	4	....	....			1.0	5

Physiology and ecology, therefore, figure largely in the botanical content of this course.

Table 23 reveals that the content of Principles of Genetics 131 is distributed into three botanical categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Fl. Pl.	Comp. Morph.	Hist.	Cyt.	Phys.- Ecol.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	19.5	9	9	2.5	2
Principles of Genetics 131	6	.....	.....	10	.....	....	....	....	84

This is a three-credit, one-quarter course, open to sophomores, juniors, and seniors who have had as a prerequisite nine credits in either botany or animal biology. In this course the fundamental principles of breeding, heredity, variation, biometry, and evolution are discussed. A knowledge of cytology would appear to have the greatest value as a preparation for this course.

COURSES IN FORESTRY

In Table 24 there are shown the categories into which the content of Dendrology 3-4 falls. This is a seven-credit, two-quarter course, which deals with 182 species of hardwood and softwood forest trees of the United States—their classification, characteristics, and range, with special attention to the prominent and constant characteristics. The botanical content of this course is divided into three categories and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Fl. Pl.	Comp. Morph.	Hist.	Cyt.	Phys.- Ecol.	Tax. Fl. Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	.....	19.5	.....	9	9	2.5
Dendrology 3-4	83	.....	.....	.....	5	.....	83	.....	.....	.....

The botanical emphasis in this course is, therefore, largely upon morphology and taxonomy of flowering plants.

Table 25 gives the proportion of time devoted to the several botanical categories in Silvics 126. The botanical content of this course is divided into two categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Fl. Pl.	Comp. Morph.	Hist.	Cyt.	Phys. Ecol.	Phys.- Ecol.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	.....	.....	19.5	9	9	2.5
Silvics 126 .....	.....	.....	.....	.....	18	82	.....	.....	.....	.....

Table 26 gives the results of the analysis of Silviculture 127. This is a three-credit, one-quarter course, devoted to a study of the general principles underlying the art of silviculture, together with a brief study of European methods as applied to American conditions. The botanical content of this course falls into one category and is contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.				Phys.-					
	Fl. Pl.	Morph.	Hist.	Cyt.	Ecol.	Ecol.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	...	19.5	9	9	2.5	.2
Silviculture 127 .....	....	.....	.....	....	25	.....	....	....	.....	....

Table 27 gives the proportion of time devoted to the several botanical categories in Silviculture 128 (laboratory). This is a seven-credit course, open to juniors and seniors, given at Cloquet during the second half of the spring quarter—six hours per day for five weeks. The course consists mainly of daily nursery and field work. The botanical content of this course is divided into two categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.				Phys.- Tax.					
	Fl. Pl.	Morph.	Hist.	Cyt.	Ecol.	Fl. Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	19.5	....	9	9	2.5	2
Silviculture (laboratory) 128 .....	....	.....	.....	....	85	4	....	....	.....	....

Tables 28 and 29 give the proportions of class periods devoted to the several botanical categories in Wood Structure and Identification, the former to the softwoods and the latter to the hardwoods. This is a six-credit, two-quarter course, open to juniors and seniors who have had Dendrology 3-4. The work consists largely of the study of the structure, identification, and classification of the most important commercial, domestic, and foreign woods. The botanical content of this course is divided into two categories and contrasted with the distribution (in per cent) of the content of General Botany 4-5-6 as follows:

	Morph. Comp.				Phys.- Tax.					
	Fl. Pl.	Morph.	Hist.	Cyt.	Ecol.	Fl. Pl.	Alg.	Myc.	Bact.	Genet.
Botany 4-5-6	18	19.5	16.5	4	19.5	....	9	9	2.5	2
Wood Structure and Identification 83-84 .....	....	.....	65.0	....	.....	15	....	....	.....	....

If General Botany 4-5-6 were to prepare the student for this course, its content would be predominantly histological in character.

Summary and Significance of the Findings.—A summary of the percentage of time devoted to the several botanical categories in the four elementary botany courses and the twenty-one sequent courses in the College of Agriculture and Forestry is found in Table II. The procedure by which these data have been deduced has been described in the preceding pages of this chapter. These statements seem warranted in so far as the limitations of the technique employed in the analyses permit.

1. All the sequent courses in the College of Agriculture and Forestry that were analyzed contain botanical constituents but in amounts varying quantitatively and to a certain degree qualitatively. The range in the amount of time devoted to botanical phases is from 5 per cent to 100 per cent. The median amount of time is 69 per cent.
2. A portion of the content of the twenty-one sequent courses analyzed deals with ecology in seventeen of the courses; taxonomy of flowering plants in seventeen of the courses; morphology of flowering plants in fifteen of the courses; physiology in thirteen of the courses; genetics in nine of the courses; plant pathology in eight of the courses; histology in four of the courses; bacteriology in four of the courses; cytology in two of the courses; and mycology in one of the courses.
3. None of the twenty-one sequent courses analyzed deals with either comparative morphology or algology.
4. The botanical content of one sequent course is distributed among eight botanical categories; of three sequent courses among seven botanical categories; of four sequent courses among six botanical categories; of one sequent course among five botanical categories; of two sequent courses among four botanical categories; of four sequent courses among three botanical categories; of five sequent courses between two botanical categories; and one sequent course is encompassed in one botanical category.
5. The botanical content of the three courses analyzed in the Division of Plant Pathology and Botany is distributed among eight botanical categories: morphology of flowering plants; taxonomy of flowering plants; physiology; mycology; ecology; histology; bacteriology; and genetics in the order named.
6. The botanical content of the five courses analyzed in the Division of Horticulture is distributed among nine botanical categories: physiology; taxonomy of flowering plants; morphology of flowering plants; ecology; genetics; plant pathology; histology; bacteriology; and cytology in the order named.
7. The botanical content of four courses analyzed in the Division of Agronomy is distributed among seven botanical categories: morphology of flowering plants; ecology; taxonomy of flowering plants; physiology; genetics; plant pathology; and bacteriology in the order named.
8. The botanical content of the eight courses analyzed in the College of Forestry is distributed among five botanical categories: ecology; histology; taxonomy

TABLE II

PERCENTAGE OF TIME DEVOTED TO THE SEVERAL BOTANICAL CATEGORIES IN ELEMENTARY BOTANY COURSES AND SEQUENT COURSES
IN THE COLLEGE OF AGRICULTURE AND FORESTRY

Course	MORPHOLOGY		PHYSIOLOGY AND ECOLOGY				TAXONOMY			GE- NET- ICS	NON- BO- TANI- CAL
	Morph. Comp. Fl. Pl. Morph.	Hist. Cyt. Phys. Ecol.	Physiol.- Ecol.	Plant Path.	Fl. Pl.	Alg. Myc. Bact.					
Elementary Botany											
Botany 4-5-6											
Lecture	17	20	15	5	12	6		9	9	3	4
Laboratory	19	19	18	3	21			9	9	2	
Lecture and laboratory...	18	19.5	16.5	4		19.5		9	9	2.5	2
Elementary Ecology 21											
Lecture		6			27	65			5	1.5	
Laboratory		34			13	53					
Elementary Plant Phys. 22											
Lecture					90	10					
Laboratory		6		2	73	16				3	
Taxonomy of Flowering											
Plants 9	35	1			3			61			
Plant Pathology and Botany											
Plant Pathology 1	19					19			30	7	1
Weeds and Grasses 7-8.....	32				16	8		26			24
Weeds and Seed Test. 9.....	42				11	5		15			18
Horticulture											
Vegetable Growing 32											
Lecture	15				24	13	4	7			27
Laboratory	6	6			26	13	7	9		2	12
Fruit Growing 6	20		1		80	15	2	6			19
										3	23

TABLE II—*Continued*

PERCENTAGE OF TIME DEVOTED TO THE SEVERAL BOTANICAL CATEGORIES IN ELEMENTARY BOTANY COURSES AND SEQUENT COURSES
IN THE COLLEGE OF AGRICULTURE AND FORESTRY

Course	MORPHOLOGY			PHYSIOLOGY AND ECOLOGY				TAXONOMY			Non- Bo- tani- cal
	Morph. Comp. Fl. Pl. Morph. Hist.	Cyt.	Phys.	Ecology	Physiol.- Ecology	Plant Path.	Tax. Fl. Pl.	Alg.	Myc.	Bact.	
Horticulture— <i>Continued</i>											
Small Fruit Culture 21.....	9		21	28		2	9				31
Systematic Pomology 111....	28						63				9
Potato Production 135.....	8		17	19		8	6			8	34
Agonomy											
Farm Crops 1	25		10	6		4	15		1		38
Grain Crops 121	21		5	9		1	18			3	43
Corn and Potato Crops 122..	19		11	16		2	4			7	41
Forage Crops 123.....	6		5	17	9	3	4		1	5	50
Principles of Genetics 131....	6	10								84	
Forestry											
Dendrology 3	33			5			33				29
Dendrology 4	33			5			33				29
Silvics 126			13	82							75
Silviculture 127				25							
Silviculture 128											
Laboratory					35		4				61
Wood Structure and											
Identification 33	65						15				20
Wood Structure and											
Identification 34	65						15				20
Forest Mensuration 7-8	2			1			2				95

of flowering plants; morphology of flowering plants; and physiology, in the order named.

9. When considered as an entity, General Botany 4-5-6 appears to be a well coordinated course, evidenced by the fact that it gives attention to the several categories proportionate to the significance which is attached to them by the authoritative opinion of botanists (in so far as this is a valid criterion) with the exception of taxonomy of flowering plants and, perhaps, plant pathology. The latter category may be considered quite analogous to mycology if, in the treatment of fungi, the pathogenic organisms are featured (which is the case as revealed by the analysis). The emphasis placed upon comparative morphology is due mainly to the supposition that a knowledge of it is essential to the complete understanding of the development of the flower. The foregoing generalization is, however, more particularly concerned with general botany from the standpoint of its functioning in the preparation of botanists rather than from the point of view with which the problem in hand is concerned; i.e., its functioning as a preparation for sequent courses in the College of Agriculture and Forestry.
10. Elementary Ecology, Elementary Plant Physiology, and Taxonomy of Flowering Plants are primarily concerned with the botanical categories with which they are respectively associated. The analysis reveals the quite intimate relationship between physiology and ecology inasmuch as 79 per cent of the time in Elementary Ecology (lecture and laboratory) and 92 per cent of the time in Elementary Plant Physiology (lecture and laboratory) are devoted to the combined categories—physiology-ecology. The analysis of Taxonomy of Flowering Plants reveals conditions similar to those found in the analysis of sequent courses; viz., that morphology of flowering plants bears a certain relationship to taxonomy. In Taxonomy of Flowering Plants 35 per cent and 61 per cent of the time are devoted to morphology of flowering plants and taxonomy of flowering plants, respectively.

Implications of the Findings.—It is obviously impossible for any elementary course in botany consisting of nine credits to fulfill the demands that might be made upon it by such an array of sequent courses as that portrayed in this chapter. By way of illustration the courses in Wood Structure and Identification and Silvics may be cited. Wood Structure and Identification devotes 65 per cent of its time to histology; Silvics devotes 82 per cent of its time to ecology. The corresponding proportions of time devoted to these categories in General Botany 4-5-6 are 16.5 per cent to histology and 6 per cent to ecology. Were the sole function of elementary botany to prepare for these two courses it might be possible to proportion its emphasis accordingly; but Wood Structure and Identification and Silvics are only two of many courses that make diverse demands upon it.

The problem of finding the most adequate adjustment whereby the elementary course might best fit the needs of all the sequent courses would appear most intricate, if not altogether incapable of solution. Although we are not warranted in drawing definite conclusions until the facts upon which these may be deduced have been definitely established through experimentation, nevertheless certain proposals present themselves that may be permissible from the data revealed by the analysis.

There is a considerable portion of the botanical content of General Botany 4-5-6, the functioning of which, as preparation for the sequent courses, might well be questioned. More specifically, these botanical constituents fall into the following categories: comparative morphology; algology; and, with the exception of its relation to one sequent course, mycology. To these three categories there is devoted approximately 37.5 per cent or over one third of the elementary botany course. Correspondingly, these three botanical categories, with the exception of mycology in plant pathology, do not enter into any of the sequent courses. One approach, then, towards adjustment of the elementary course might be to supplant these seemingly non-essential constituents with those which appear to be more essential; i.e., introduction of some treatment of taxonomy of flowering plants and a greater proportionate treatment of morphology of flowering plants, ecology, and physiology.

The fact deduced from the analysis (see 2 above)—that the four outstanding categories are ecology, taxonomy of flowering plants, morphology of flowering plants, and physiology, when considered from the standpoint of the extent to which they are common to the greatest number of sequent courses—might augur for special emphasis on the training of all students in these four categories in the elementary course in botany. However, another deduction of perhaps greater significance is that diversification in preparatory training, depending upon the subsequent specialization of the student, might be warranted. Illustrative of this, for the student specializing in plant pathology and botany (see 5 above), morphology of flowering plants, taxonomy of flowering plants, physiology, and mycology receive the greatest emphasis in the order named in his subsequent work; and, correspondingly, these categories would receive the greatest emphasis in the preparatory training of this particular student. Similarly, it follows for the student in horticulture (see 6)—physiology, taxonomy, morphology of flowering plants, and ecology; for the student in agronomy (see 7)—morphology of flowering

plants, ecology, taxonomy, and physiology; for the student in forestry (see 8)—ecology, histology, taxonomy of flowering plants, and morphology of flowering plants.

The supposition was advanced in Chapter II that since the time devoted to General Botany had been gradually reduced from twenty-four to nine quarter hours, it might be inferred that the treatment of the various categories would be necessarily curtailed or even superficial as a result. The proposal is advanced that, since a more detailed as well as a more specialized preparation than now exists might be desirable, a part of the time now given to General Botany be supplanted by one or more of the special courses—Elementary Plant Physiology, Elementary Ecology, and Taxonomy of Flowering Plants, which now devote practically their entire time to the special categories: physiology, ecology, and taxonomy, respectively. The content of General Botany would then be devoted primarily to general morphology. General Botany is now a prerequisite for these elementary special courses; but it is conceivable that in lieu of this there might be introduced into their content those prerequisite elements that are essential. These elements might be embodied in the content at the particular time when they would have the greatest functional value, thereby serving to motivate the student in their acquisition when a need for them is detected. As a concrete illustration, the preparatory training of the student would then consist of (1) four credits in General Botany made up largely of the elements of morphology with its physiological correlates, experimentally determined essential for all students; (2) two of the special courses—Elementary Ecology, Elementary Plant Physiology, or Taxonomy of Flowering Plants (each three credits) elected upon the basis of future specialization. In certain cases all three of the special courses might be taken to advantage. In the case of specialization in plant pathology, a course in Elementary Mycology might be a desirable substitute.

Whereas the contents of the various sequent courses have been distributed to the several botanical categories, a study of the elements in a given course assigned to a particular category reveals them to be largely specific in nature. By way of illustration, taxonomy in forestry deals with specific hardwood and softwood trees; in horticulture with specific fruits and vegetables; in agronomy with specific cereal and forage plants; and in agricultural botany with specific weeds and grasses. The same is true of ecology, physiology, and the other cate-

gories. The functioning of these elementary courses as preparation for the sequent courses, then, would appear to be proportional to the extent to which they build up the principles or underlying structure upon which subsequent treatment in the sequent courses might depend.

PROBLEM II

Purpose.—The second investigation reported in this chapter was made in order to determine the effect of previous preparation in elementary botany upon the subsequent achievement of students in certain sequent courses.

Sources and Method.—Quite obviously, the most significant method of determining the effect of previous preparation upon the achievements of students in a sequent course would be to conduct an experiment with two groups of students comparable in all respects, save that one group had had the preparatory course, while the other had not.

There are several limitations placed upon this type of procedure in a university organization. In the first place, students during the first two years in the College of Agriculture take quite the same course of study; and since botany is not only one of the required courses taken by all students, generally in the freshman year, but also a prerequisite to most of the sequent courses discussed here, it is not possible to secure comparable groups, one with, and the other without, previous botanical training. Moreover, the number of students in any given course becomes less as the advanced courses are reached, so the possibility of securing two comparable groups of significant size presents a problem. If, however, it might be possible to waive the botanical requirement for half the number of incoming freshmen in a given year and then compare their achievement in subsequent years with that of an equated group composed of the other half, who had completed the elementary course in botany, this should afford the conditions for a highly desirable procedure in the solution of this problem.

Whereas it was impossible to find conditions in most of the sequent courses where there was a variation in the previous botanical training of the students entering them, due to the fact that botany is a prerequisite to their entrance, nevertheless in certain courses, viz., Farm Crops 1, Vegetable Growing 32, and Fruit Growing 6, this condition of variation in preparation was found to exist. Farm Crops 1 and either Vegetable Growing 32 or Fruit Growing 6 are subjects required of all students

in the College of Agriculture, generally in the freshman year. Not all of the students entering these courses will, therefore, have had General Botany 4-5-6. This status exists because, due to difficulties in arranging programs of study and variation in the quarter at which matriculation takes place in the University, some students may take these courses in their sophomore year or even later. The same argument holds for General Botany 4-5-6 in that not all students take this course in their freshman year.

From the analyses of Farm Crops 1, Fruit Growing 6, and Vegetable Growing 32, as shown in Table II, their contents were found to be distributed (in per cent) in the following botanical categories:

	Morph.			Pl. Tax.			Genet-Non-		
	Fl. Pl.	Cyt.	Hist.	Phys.	Ecol.	Path.	Fl. Pl.	Bact.	ics Bot.
Farm Crops 1	25	....	....	10	6	4	15	1	38
Fruit Growing 6	20	1	....	30	15	2	6	....	23
Vegetable Growing 32									
Lecture	15	....	....	24	13	4	7	....	27
Laboratory	6	....	6	26	13	7	9	2	19

It was deemed desirable, therefore, to compare the achievements of students with and without previous preparation in botany in these courses, since they are quite representative of all the sequent courses in the distribution of their content. The basis of comparison was the achievement of the two groups of students—those with, and those without, botany, on a final objective test given in each course at the time of its completion. The tests in Farm Crops, Vegetable Growing, and Fruit Growing consisted of 100, 200, and 150 items, respectively, and called for responses of the true-false, multiple choice, and completion types (see Appendix for the respective tests). A comparison was also made of the relative abilities of students in the two groups on the basis of honor point ratios. These ratios were determined by dividing the sum of the honor points attained by each student from the university courses taken (an A = 3 honor points for each credit; B = 2 honor points; C = 1 honor point; D = 0 honor points; F = - 1 honor point) by the total number of credits.

Findings.—Table III shows the relative achievement of two groups in Farm Crops 1, fall quarter, one with, the other without, previous preparation in botany at the time of entrance to the course. The mean achievement of the group with botany was 86.7 ± 10.1 ; of the group without botany, 85.9 ± 10.5 . The mean honor point ratios of the two

groups were .826 and .878, respectively. A botany test (explained in the subsequent chapter) was given to the class at the beginning of the course. The mean scores on this test were 56.1 for the group with botany, and 3.6 for the group without botany.

TABLE III

ACHIEVEMENT OF STUDENTS IN FARM CROPS WITH AND WITHOUT PREVIOUS PREPARATION IN GENERAL BOTANY 4-5-6, FALL QUARTER, 1927

WITH BOTANY				WITHOUT BOTANY			
Student's No.	Honor Point Ratio	Botany Test Score	Achieve. Test Score	Student's No.	Honor Point Ratio	Botany Test Score	Achieve. Test Score
1	.916	57	99	1	1.540	8	99
2	.769	123	96	2	2.151	0	97
3	.949	27	93	3	.352	0	91
4	1.674	73	87	4	1.454	14	89
5	1.068	78	86	5	2.096	3	88
6	.031	26	79	6	.785	7	85
7	.376	9	67	7	.357	0	85
				8	-1.000	0	78
				9	.166	0	61
M	.826	56.1	86.7		.878	3.6	85.9
SD	$\pm .483$	± 36.3	± 10.1		$\pm .96$	4.8	± 10.5

Table IV gives the achievement of students in Farm Crops 1, with and without previous preparation in General Botany 4-5-6, at the end of the winter quarter. The mean achievement of the group with botany was 83.9 ± 9.03 ; of the group without botany, 81.7 ± 8.8 . Their honor point ratios were 1.063 and 1.022, respectively.

Table V shows the achievement of students in Vegetable Growing 32 with and without previous preparation in General Botany 4-5-6. The mean achievement of the group with botany was 169.8 ± 13.2 ; of the group without botany, 167.1 ± 11.8 . Their respective honor point ratios were 1.226 and 1.368.

Table VI gives the achievement of students in Fruit Growing 6, with and without General Botany 4-5-6. The mean achievement of the group with botany was 116 ± 24.6 ; of the group without botany, 121.3 ± 33.3 . The honor point ratios were 1.558 and 1.603, respectively.

Table VII gives the reliability of the differences between the

TABLE IV

ACHIEVEMENT OF STUDENTS IN FARM CROPS WITH AND WITHOUT PREVIOUS
PREPARATION IN GENERAL BOTANY 4-5-6, WINTER QUARTER, 1928

WITH BOTANY			WITHOUT BOTANY		
Student's No.	Honor Point Ratio	Achieve. Test Score	Student's No.	Honor Point Ratio	Achieve. Test Score
1	1.823	96	1	2.794	89
2	1.187	95	2	1.058	89
3	1.254	94	3	1.311	88
4	1.458	93	4	2.762	87
5	.769	91	5	6.20	87
6	.636	91	6	.571	84
7	1.705	89	7	1.000	84
8	.705	89	8	1.000	83
9	1.076	88	9	.750	77
10	.552	86	10	---.625	72
11	.183	86	11	.000	59
12	1.700	85			
13	1.595	82			
14	2.244	82			
15	.666	79			
16	1.555	76			
17	.312	75			
18	.370	69			
19	.761	68			
20	.765	65			
M	1.063	83.9		1.022	81.7
SD	$\pm .57$	± 9.03		$\pm .98$	± 8.8

achievement of students with preparation in General Botany and that of students without preparation in the following courses: Farm Crops, Fruit Growing, and Vegetable Growing. As it is customary to take a

$\frac{D}{\sigma_{(diff)}}$ of 3 as indicative of complete reliability, it is observed that

none of the values for $\frac{D}{\sigma_{(diff)}}$ approach this criterion. Therefore, for these particular groups of students, as measured by these particular tests, previous training in botany apparently makes no significant difference, as far as achievement in Farm Crops, Fruit Growing, and Vegetable Growing is concerned.

TABLE V

ACHIEVEMENT OF STUDENTS IN VEGETABLE GROWING WITH AND WITHOUT PREVIOUS
PREPARATION IN GENERAL BOTANY 4-5-6

WITH BOTANY			WITHOUT BOTANY		
Student's No.	Honor Point Ratio	Achieve. Test Score	Student's No.	Honor Point Ratio	Achieve. Test Score
1	1.634	196	1	2.353	178
2	1.585	190	2	1.000	178
3	.885	166	3	2.344	177
4	1.496	182	4	1.102	177
5	1.567	181	5	1.454	169
6	2.204	179	6	.819	166
7	1.310	179	7	1.826	158
8	1.518	178	8	1.887	188
9	1.826	173	9	2.580	170
10	1.155	171	10	1.428	168
11	1.595	170	11	1.000	163
12	1.197	164	12	.500	152
13	1.076	161	13	.521	151
14	.463	156	14	.342	145
15	.486	155			
16	1.000	144			
17	.487	142			
18	1.306	193			
19	1.355	190			
20	2.039	188			
21	2.244	187			
22	2.016	184			
23	1.269	182			
24	1.238	181			
25	1.417	177			
26	.704	174			
27	1.653	174			
28	1.153	169			
29	.783	169			
30	1.560	172			
31	1.571	164			
32	1.246	162			
33	1.393	162			
34	1.060	160			
35	.370	159			
36	.824	159			
37	1.016	158			
38	.740	157			
39	.097	157			
40	.638	157			
41	.681	155			
42	1.639	154			
M	1.226	169.8		1.368	167.1
SD	$\pm .5$	± 13.2		$\pm .65$	± 11.8

TABLE VI
ACHIEVEMENT OF STUDENTS IN FRUIT GROWING WITH AND WITHOUT PREVIOUS
PREPARATION IN GENERAL BOTANY 4-5-6

WITH BOTANY				WITHOUT BOTANY			
Student's No.	Honor Point Ratio	Botany Test Score	Achieve. Test Score	Student's No.	Honor Point Ratio	Botany Test Score	Achieve. Test Score
1	2.709	127	157	1	2.785	33	165
2	1.355	25	146	2	2.357	25	158
3	1.326	59	132	3	2.794	17	156
4	1.826	105	132	4	2.762	12	151
5	1.301	.....	129	5	1.780	6	130
6	1.595	44	129	6	1.187	19	128
7	1.281	37	121	7	1.454	14	121
8	1.823	58	122	8	1.785	11	121
9	2.201	40	117	9	1.642	5	120
10	1.8	....	119	10	1.555	....	118
11	1.254	66	112	11	.133	4	95
12	1.674	73	91	12	.552	7	59
13	1.086	....	91	13	.052	8	55
14	1.571	85	83				
15	.566	23	59				
M	1.558	61.8	116		1.603	13.4	121.3
SD	±.482	±29.9	±24.6		±.8	±6.7	±33.3

It was considered desirable to determine whether or not there was any significant difference in the per cent of correct responses to questions, which might be classified as either botanical or non-botanical in character. For example, items in the Farm Crops test such as: "The requirements for the germination of seeds are *moisture, oxygen, and heat,*" or "The parts of a corn leaf are *blade, sheath, and ligule,*" might be said to be botanical in character; while such items as: "The weight per bushel of brome grass is *14 pounds*, alfalfa *60 pounds*, and red clover *60 pounds,*" or "Foreign red clover seed is stained *10 per cent red,* when it is unadapted to this country" might be said to be non-botanical in character. The items in the tests given in Farm Crops and Fruit Growing were classified into the two categories, botanical and non-botanical. The per cent of correct responses to each item by the group of students with previous training in botany and by the group without previous training was determined.

TABLE VII

THE RELIABILITY OF THE DIFFERENCE BETWEEN THE ACHIEVEMENT OF STUDENTS
WITH AND WITHOUT PREPARATION IN GENERAL BOTANY 4-5-6

COURSE	MEAN SCORE		MEAN SCORE		D	$\frac{D}{\sigma_{(diff)}}$	
	WITH BOTANY	SD	WITHOUT BOTANY	SD			
Farm Crops 1..... (fall quarter)	86.7	± 10.1	85.9	± 10.5	0.8	5.2	.154
Farm Crops 1..... (winter quarter)	83.9	± 9.03	81.7	± 8.8	2.2	3.4	.65
Fruit Growing	116.0	± 24.6	121.3	± 33.3	5.3	11.1	.47
Vegetable Growing.....	169.8	± 13.2	167.1	± 11.8	2.7	3.7	.73

Table 30 gives the character and number of errors committed on the achievement test in Farm Crops by students with and without previous preparation in General Botany 4-5-6. The per cent of correct responses of the group with botany to items botanical in character is 73.4; to items non-botanical in character, 70.5. The per cent of correct responses of the group without botany to items botanical in character is 73.8; to items non-botanical in character is 72.8. The difference between the per cent of correct responses of the group with botanical training to items botanical in nature and that of the group without botanical training to items botanical in nature is 4.6. The difference between the per cent of correct responses of the group with botanical training to items non-botanical in nature and that of the group without botanical training to items non-botanical in character is 2.3. It would seem, then, that the group without botany is not handicapped to any appreciable extent in its responses to items of a botanical nature.

Table 31 gives the character and number of errors committed on the achievement test in Fruit Growing by students with and without previous preparation in General Botany 4-5-6. The per cent of correct responses of the group with preparation in botany to items botanical in character is 75.2; to items non-botanical in character, 69.2. The per cent of correct responses of the group without botany to items botanical in character is 84.1; to items non-botanical in character is 79.1. The difference between the per cent of correct responses of the group with botanical training to items botanical in nature and that of the group without botanical training to items botanical in character is 8.9. The difference

between the per cent of correct responses of the group with botanical training to items non-botanical in nature and that of the group without botanical training to items non-botanical in character is 9.9. As a matter of fact, the group without botanical training secured a higher percentage of correct responses to both non-botanical and botanical items than did the group with botanical training. It appears, therefore, that the superiority of the group without previous botanical training (although not significant, as previously shown) over that of the group with previous botanical training is due to more correct responses to both botanical and non-botanical items.

What, then, may be the explanation of the apparently insignificant differences in achievement between the group of students with botanical training and the group without botanical training in such courses as Farm Crops, Vegetable Growing, and Fruit Growing. Although a limitation is placed upon the drawing of conclusions from the resulting data, due to the number of students involved, nevertheless certain implications may be permissible. Perhaps the fact that the groups of students designated as without previous botanical training were also beginning General Botany 4-5-6 at the same time that they were beginning Farm Crops (fall quarter) and Fruit Growing might account for the lack of no significant differences between their achievements in these courses and those of the groups with previous botanical training. This, however, would not hold true in accounting for the insignificant differences obtained in the Vegetable Growing and Farm Crops courses (winter quarter), for in these cases the groups designated as without previous botanical training were not enrolled in General Botany 4-5-6. It seems that a more plausible explanation may be found by an analysis of the data given in Tables VIII and IX.

Table VIII gives the common topics of treatment in General Botany 4-5-6 and Farm Crops. Table IX gives the common topics of treatment in General Botany 4-5-6 and Vegetable Growing. These data were obtained by an analysis of the course contents to determine the topics that were discussed in both the courses in General Botany 4-5-6 and the sequent courses. From this it is observed that in Vegetable Growing and Farm Crops a considerable amount of elementary botany is taught, which is deemed essential as preparatory to the more specific type of botanical material in their content. This, then, would seem to be an explanation for the lack of significant differences, since those students

without previous training in botany would obtain the elementary botanical knowledge deemed necessary in the sequent course itself, while those students who had had previous training in botany would simply review work previously taken.

TABLE VIII

COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND FARM CROPS 1

TOPIC	FARM CROPS 1	BOTANY 4-5-6
Leaves		
Components		
Blade	x	x
Petiole	x	x
Sheath	x	x
Stipule	x	x
Collar	x	x
Ligule	x	x
Function	x	x
Simple and compound.....	x	x
Venation	x	x
Origin	x	x
Arrangement	x	x
Special application to leaves of legumes and grasses including corn	x	
Stems		
Origin	x	x
Regions of growth	x	x
Nodes	x	x
Internodes	x	x
Stooling, tillering, or suckering.....	x	x
Prostrate	x	x
Buds	x	x
Classification of plants on the basis of length of life		
Summer annuals	x	
Spring annuals	x	
Fall annuals	x	
Classification of plants on the basis of vegetative forms		
Herbs	x	x
Shrubs	x	x
Trees	x	x
Special application to stems of legumes and grasses including corn	x	

TABLE VIII—*Continued*

COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND FARM CROPS 1

TOPIC	FARM CROPS 1	BOTANY 4-5-6
Roots		
Classes		
Tap	X	X
Fibrous	X	X
Distinction between underground stem and root		
Quack grass	X	X
Stolons	X	X
Region of growth	X	X
Structure	X	X
Function	X	X
Special applications to field crops.....	X	
Legume nodules		
Causal agent—bacteria	X	X
Relation to nitrogen fixation.....	X	X
Symbiosis	X	X
Inoculation	X	
Application to agronomy	X	
Inflorescence		
Grass spike		
Rachis	X	X
Pedicle		
Sessile	X	X
Spikelets		
Sides	X	X
Furrow	X	
Glumes	X	X
Sections of wheat kernel.....	X	X
Bracts or glumes		
Palea	X	X
Nature	X	X
Fertile and sterile flowers.....	X	X
Rachilla	X	X
Structure of flower		
Stamens		
Filament	X	X
Anther	X	X
Pollen	X	X
Pistils		
Ovary	X	X
Style	X	X
Stigma	X	X

TABLE VIII—*Continued*

COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND FARM CROPS 1

TOPIC	FARM CROPS 1	BOTANY 4-5-6
Special application to wheat plant.....	x	
Grass panicle		
Rachis	x	x
Nodes	x	x
Internodes	x	x
Branches	x	x
Pedicle	x	x
Sterile flower		
Glumes	x	x
Fertile flower		
Outer glumes	x	x
Palea	x	x
Flowering glumes	x	x
Wild oats		
Awn	x	
Basal hairs	x	
Special application to the oat plant		
Contrast with corn	x	
Special study of corn.....	x	
Legume inflorescence	x	x
Papilionaceous flower		
Stamen		
Monadelphous	x	x
Diadelphous	x	x
Distinct	x	x
Pistil		
One or more stigma.....	x	x
Single	x	x
Ovary in one chamber or more.....	x	x
Calyx		
Teeth	x	x
Corolla		
Standard	x	x
Wings	x	x
Keel	x	x
Regular or irregular	x	x
Terminal, lateral, or both.....	x	x
Bisexual flowers	x	x
Unisexual flowers	x	x
Plant of floral structure		
Arrangement of parts in 3's, 4's, or 5's, etc.....	x	x

TABLE VIII—*Continued*

COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND FARM CROPS 1

TOPIC	FARM CROPS 1	BOTANY 4-5-6
Complete flower	x	x
Incomplete flower	x	x
Fertilization	x	x
Seed pods		
Attachment of seeds	x	x
Dehiscence	x	x
Fruit and Seed		
Distinction between	x	x
Development of pistil and its contents into fruit (true or false)	x	x
Corn kernel, fruit or seed.....	x	x
Wheat kernel, fruit or seed.....	x	x
Grass seeds, fruit or seed	x	
Dicotyledonous seeds		
Seed-coat	x	x
Hilum	x	x
Cotyledons		
Function	x	x
Plumule		
Function	x	x
Radicle		
Part played in growing plant.....	x	x
Ovary wall	x	x
Special applications to legumes.....	x	
Monocotyledonous seeds		
Embryo		
Plumule	x	x
Radicle	x	x
Endosperm	x	x
Cotyledon	x	x
Germination of seeds		
Special application to corn.....	x	

For the effect which training in elementary botany might have upon the achievement of students in the sequent courses other than those discussed above no significant data are available. The only data that might be considered to bear some relationship to this problem are those presented in Table X (a) which gives the coefficients of correlation between grades attained by students in General Botany 4-5-6 and cor-

responding grades in certain sequent courses; also those shown in Table X (b) which gives the coefficients of correlation between scores on a botany test (described in the subsequent chapter) and grades in certain sequent courses. As a possible basis of comparison, the coefficients of correlation were computed between grades in General Botany 4-5-6 and grades in three more or less distinct types of sequent courses; between scores on the botany test and the grades in three more or less distinct types of courses. The first of these types includes courses that are largely botanical in character as revealed by the analysis (see Table II), viz., Plant Pathology, Wood Structure and Identification, and Silvics; the second, a course rather limited in botanical content, viz., Principles of Genetics; and the third, a group of courses almost exclusively non-botanical, viz., Forest Mensuration and General Agricultural Biochemistry.

TABLE IX
COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND
VEGETABLE GROWING

TOPIC	COURSE	
	Vegetable Growing	Botany 4-5-6
Leaves		
Structure		
Epidermis	x	x
Mesophyll tissue	x	x
Palisade parenchyma	x	x
Spongy parenchyma	x	x
Border parenchyma	x	x
Absciss-layer	x	x
Cross sections of leaves of spinach, lettuce, cabbage, chard, rhubarb, onion bulb.....	x	
Portion of bulb of leafy structure.....	x	
Stems		
Dicotyledonous		
Structure		
Primordial meristem	x	x
Protoderm	x	x
Ground meristem	x	x
Procambium strands	x	x
The three primary meristems.....	x	x
Primary permanent tissues.....	x	x
Epidermis	x	x

TABLE IX—*Continued*
COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND
VEGETABLE GROWING

TOPIC	COURSE	
	Vegetable Growing	Botany 4-5-6
Primary cortex	X	X
Pericycle	X	X
Primary medullary rays.....	X	X
Pith	X	X
Phloem	X	X
Fascicular cambium	X	X
Xylem	X	X
Vascular bundle	X	X
Sieve tubes	X	X
Companion cells	X	X
Phloem parenchyma	X	X
Tracheal tubes	X	X
Tracheids	X	X
Wood fibers	X	X
Wood parenchyma	X	X
Nature of herbaceous stem of dicotyledons.....	X	X
Monocotyledonous		
Structure	X	X
Portion of bulb of stem structure.....	X	X
Cross and long section of asparagus tip, potato tuber, swollen part of kohlrabi stem, onion bulb, girasole tuber	X	
Root		
Root cap	X	X
Growing point	X	X
Region of elongation	X	X
Zone of root hairs.....	X	X
Mature region	X	X
Structure		
Epidermis	X	X
Cortex	X	X
Endodermis	X	X
Pericycle	X	X
Vascular cylinder	X	X
Stele	X	X
Cross and long sections of carrot, salsify, or radish root	X	

TABLE IX—*Continued*
COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND
VEGETABLE GROWING

TOPIC	COURSE	
	Vegetable Growing	Botany 4-5-6
Gross morphology or structure of the flower		
Gynœcium		
Carpel	X	X
Pistil		
Ovary	X	X
Style	X	X
Stigma	X	X
Stigmatic fluid	X	X
Locule	X	X
Ovule	X	X
Ventral suture	X	X
Dorsal suture	X	X
Placenta	X	X
Andrœcium		
Filament	X	X
Anther	X	X
Perianth		
Corolla	X	X
Calyx	X	X
Peduncle	X	X
Pedicel	X	X
Pattern flower	X	X
Staminate flower	X	X
Pistillate flower	X	X
Hermaphrodite	X	X
Diœcious species	X	X
Monœcious species	X	X
Syncarpy	X	X
Synandry	X	X
Sympetaly	X	X
Synsepaly	X	X
Epipetaly	X	X
Hypogyny	X	X
Perigyny	X	X
Epigyny	X	X
Grass spikelet	X	X
Composite head	X	X

TABLE IX—*Continued*
COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND
VEGETABLE GROWING

TOPIC	COURSE	
	Vegetable Growing	Botany 4-5-6
Knowledge of floral structure preliminary to the technique of crossing or selfing vegetable crop plants	x	
Principles of genetics applied in the improvement of vegetable crops		
Dominance, unit characters, segregation.....	x	x
Factor or gene	x	
Allelomorph	x	
Homozygous and heterozygous individuals.....	x	
Genotype and phenotype	x	
Fruit		
In the popular sense.....	x	
In the botanical sense.....	x	x
Legume	x	x
Grain	x	x
Berry	x	x
Pepo	x	x
Schizocarp	x	x
Cross and long sections.....	x	x
Pea, bean	x	x
Sweet corn	x	x
Tomato, pepper, huckleberry, husk tomato.....	x	
Cucumber, squash	x	
Dill	x	
Seeds		
Hilum	x	x
Micropyle	x	x
Raphe	x	x
Endosperm	x	x
A unisporangiate, unisporiate, trigenerational unit	x	
Cross and long sections		
Exalbuminous dicotyledonous type		
Bean, pea, cucumber	x	
Albuminous dicotyledonous type		
Beet, potato	x	
Albuminous monocotyledonous type		
Sweet corn, asparagus, onion	x	

TABLE IX—*Concluded*
COMMON TOPICS OF TREATMENT IN GENERAL BOTANY 4-5-6 AND
VEGETABLE GROWING

TOPIC	COURSE	
	Vegetable Growing	Botany 4-5-6
Germination		
Those having a period of delayed germination		
Husk tomato	x	
Those having no period of delayed germination		
Bean or pea.....	x	
Sprouting temperatures		
Variation	x	
Moisture	x	x
Aeration	x	x
Other methods of propagation		
Cuttings: sweet potato; tomato.....	x	
Hardwood cuttings: rosemary.....	x	
Tuber and tuber division: potato; girasole.....	x	
Crown and root division: rhubarb.....	x	
Root division: horse-radish.....	x	
Suckers: perennial husk tomato.....	x	
Bulbs: bottom offsets—chive, garlic, shallot.....	x	
Bulbs: top offsets—Egyptian onion.....	x	
Essential elements in plant growth		
Effect of limiting elements in:		
Vegetable crops grown for fruits	x	
Vegetable crops grown for stem and leaves.....	x	
Vegetable crops grown for storage stems	x	
Vegetable crops grown for storage roots	x	
Vegetable crops grown for storage leaves	x	
Effect of relatively high temperature on plants.....	x	x

Although such limiting factors as the number of cases, the unreliability of teachers' marks and the validity of the rank-difference method of computing the coefficient of correlation, render untenable any definite conclusions, such implications as the following may not be altogether unwarranted:

1. The courses highest in botanical content—Plant Pathology, Wood Structure and Identification, and Silvics [see Table X (a)]—show the highest coefficient of correlation between grades attained in them and grades attained in General Botany. The same holds true for the coefficient [Table X (b)] of correlation

TABLE X (a)

COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN GRADES IN
GENERAL BOTANY 4-5-6 AND GRADES IN SEQUENT COURSES

No. STUDENTS	SEQUENT COURSE	ρ	k	PER CENT OF RELATIONSHIP
19	Plant Pathology	$.84 \pm .05$	.54258	.6075
21	Wood Structure and Identifica- tion	$.62 \pm .10$	.78460	.4415
18	Silvics	$.60 \pm .11$	.80000	.4286
11	Grain Crops	$.51 \pm .18$	.86012	.3722
26	Principles of Genetics.....	$.57 \pm .09$	.82164	.4095
35	Forest Mensuration	$.55 \pm .08$	.83576	.3970
19	General Agricultural Bio- chemistry	$.57 \pm .11$	.82164	.4095

TABLE X (b)

COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN SCORES
ON BOTANY TEST AND GRADES IN SEQUENT COURSES

No. STUDENTS	SEQUENT COURSE	ρ	k	PER CENT OF RELATIONSHIP
12	Plant Pathology	$.74 \pm .12$	.67260	.5238
20	Wood Structure and Identifica- tion	$.56 \pm .10$	.82849	.4033
20	Silvics.....	$.74 \pm .08$	.67260	.5238
22	Farm Crops	$.44 \pm .12$	.89799	.3288
24	Fruit Growing	$.26 \pm .13$	.96560	.2120
14	Principles of Genetics.....	$.46 \pm .14$	.88791	.3412
38	Forest Mensuration	$.42 \pm .09$	.90752	.3160
17	General Agricultural Bio- chemistry	$.24 \pm .08$	.97077	.1982
24	Phytochemistry	$.10 \pm .14$	.99498	.0913

between grades in such courses and scores on the botany test. Of these three courses, the one having the greatest number of botanical categories in which its constituents are distributed—Plant Pathology—shows the highest correlation between grades attained in it and grades in General Botany.

2. Conversely, the course of limited botanical content—Principles of Genetics—and the courses practically non-botanical in character—Forest Mensuration and General Agricultural Biochemistry—show lower correlations than those found in 1. The differences are more apparent in the correlations between scores on the botany test and grades in sequent courses than between grades in General Botany and grades in sequent courses.

3. With the exception of Silvics, the correlations between grades in General Botany and grades in sequent courses are higher than the correlations obtained between scores on the botany test and grades in sequent courses.
4. The correlations between the scores on the botany test and grades in Farm Crops and Fruit Growing, $.44 \pm .12$ and $.26 \pm .13$, respectively, are such as might be expected since, as previously discussed, no significant differences were found in the achievement in these courses of students with and without previous preparation in botany.
5. Achievement in Phytochemistry (largely non-botanical in nature) does not seem to bear any relationship to the amount of botanical knowledge, as evidenced by scores attained on the botany test, which students (mostly graduate) have upon entrance to this course.
6. Whether or not previous training in botany manifests itself in these higher coefficients of correlation between grades attained in courses higher in botanical content and grades in General Botany cannot be unequivocally stated. The interpretation probably lies in the supposition that more nearly identical abilities would be called for in such courses as Plant Pathology and General Botany than in such courses as Forest Mensuration and General Botany. The rather high correlations displayed in all the comparisons are probably a result of the functioning of general intelligence; but the combined action of many factors, dependent on each other or perhaps interwoven in a very complex manner, is likely to render any inductions tentative.

Implications of the Findings.—One of the implications resulting from this study, in so far as the findings reported are valid, might be a different allocation in the curriculum of such courses as Farm Crops, Fruit Growing, and Vegetable Growing. For example, they might be moved up into the junior year so that at the time of entrance the students would have had an equal amount of training in botany. This might obviate the necessity for instruction in elementary botany, which in the present state seems necessary in these courses due to the variable preparation of the students enrolled. By the suggested arrangement the time now devoted to instruction in elementary botany might be given to an enrichment of content on a higher level, since it might be inferred that the students by this time would have received basic training, not only in botany, but in other sciences. This relationship would seem to depend upon how well the elementary courses fulfilled their function as prerequisites.

On the other hand, it appears that certain desirable features of these courses in their present state might call for maintaining them in their present position in the curriculum. In the first place, these courses may re-enforce and supplement the elementary botanical knowledge of

the student. The necessity for re-enforcement may be one of the implications resulting from data on the permanence of learning in botany (see Chapter IV). The desirability of supplementary botanical knowledge might lie in the extent to which these courses provide more specific botanical knowledge or training, which would have functional value for the more specialized courses in these fields; namely, Farm Crops 1 as preparatory to Advanced Farm Crops, etc. Then, again, these courses may assist in orientating the student preliminary to his subsequent specialization, since this specialization does not ordinarily occur until the junior year. Finally, in order to motivate the student it may be desirable to introduce such courses as early as possible in the curriculum, lest, if his course of study should consist chiefly of the basic sciences, the student might lose interest in those particular professional phases of the career for which he is training. That is, the student might not establish the connection between so much training in the basic sciences and the postponement of opportunities for the application of certain principles deduced from such study. The above-mentioned implications would seem to merit their validation through controlled experimentation.

In so far as the coefficients of correlation obtained between the grades in elementary botany and grades in certain sequent courses permit an interpretation of this relationship on the basis of common factors in intelligence or common abilities involved, it would seem desirable that the elementary course in botany be so organized and taught as to bring about the optimum development of these abilities, in order that they might thereby function more expeditiously in the sequent courses for which they form the basis.

CHAPTER IV

THE PERMANENCE OF LEARNING IN ELEMENTARY BOTANY

The Problem.—The study reported in this chapter was an attempt to determine: (1) the extent of retention of the botanical information acquired by the student in the course in General Botany; (2) the relationship between the amount retained and the initial amount possessed; (3) the nature of the material retained; and (4) any apparent effect of the amount of previous botanical information upon achievement in sequent courses.

Sources and Method.—It seemed desirable, in the consideration of the functioning of elementary botany as a prerequisite course, to obtain some measure of the retention or carry-over of botanical knowledge from the time the course was taken until the time of entrance to the sequent courses for which botany is a prerequisite. This necessitated the construction of a valid measuring instrument.

There had been given during the year 1926-1927 a final objective examination at the end of each quarter's work in General Botany 4-5-6. Accordingly, there were three final objective examinations which covered the content of the course. The aggregate of items comprising these tests was 587, of which 265 were of the true-false and 322 of the completion type. A test educed from this source seemed preferable to any that might be compiled by the investigator, since by means of it one had a measure of what each student had done at the time of completing each quarter's work. Then, by giving the same test at the beginning of the fall quarter, 1927-1928, a measure should be obtained of the retention for intervals of nine, six, and three months, which had elapsed since the student had completed General Botany 4, 5, and 6, respectively.

One of the criteria of a good examination is its administrative feasibility. Although, from the standpoint of securing greater validity, it might have been desirable to have given the composite test of 587 items, nevertheless it was necessary to select from this composite, items in such numbers as to constitute a representative and comprehensive examination, capable of being given in two hours. Other things being equal, that test is best in which the items range in regular intervals from very

easy to very difficult ones. The procedure for securing this arrangement is to record the frequency of error on each of the items of the test. In this way the relative difficulty of the respective items may be determined. This method or means is greatly enhanced by a large number of cases. For the selection of the items of the test in question, there were available final examinations for 108 students in General Botany 4; for 89 in General Botany 5, and for 58 in General Botany 6. The frequency of error for each item determined by an analysis of these papers is given in Table 32. There were found 54 students who had taken the three quarters of General Botany 4-5-6. An analysis of their test papers is found in Table 33. On the basis of the latter analysis, ninety true-false statements (thirty from each of the tests for General Botany 4-5-6); forty-seven completion items from General Botany 4; forty-four completion items from General Botany 5, and fifty-two completion items from General Botany 6 were chosen. The basis of selection was the degree of difficulty of the item as determined by its frequency of error. An attempt was made to secure a maximum number of easy and difficult items with all intermediate steps represented. The true-false items were arranged in order of difficulty (by units of three items of the same difficulty, as far as frequency of error is a valid means of determining this difficulty). The completion items did not lend themselves entirely to this arrangement, since they are constituents of sentences which, in turn, are in many cases components of paragraphs. This selection of items did not seem to be as representative of botanical content as desired. Accordingly, there were added to the items selected, 36 true-false statements and 29 completion items. The test, then, in the form in which it was given consisted of 126 true-false statements and 172 completion items, or a total of 298 items. A copy of this test¹ as well as one of the complete original examination² from which its items were selected is given in the Appendix.

In addition to administrative feasibility, validity and reliability are principal criteria of good examinations. The validity of the test used in this study was determined by correlating the scores attained on it by the examinees and their grades in General Botany 4-5-6. The basis for the determination of the students' grades in General Botany 4-5-6 was secured by adding one-third of the grade given in laboratory work,

¹ *Infra*, pp. 170-178.

² *Infra*, pp. 157-170.

one-third of the grade on quizzes (mainly objective), and one-third of the score on the final examination. Table 34 gives the grades of fifty-four students in Botany 4-5-6 by quarters and their corresponding scores on the botany test. Table XI gives the total grade received for the three quarters' work in General Botany 4-5-6 and the corresponding score on the botany test for the same fifty-four students. The coeffi-

TABLE XI

CORRELATION BETWEEN TOTAL SCORES ON BOTANY TEST AND TOTAL FINAL GRADES
IN GENERAL BOTANY 4-5-6

STUDENT'S No.	BOTANY 4-5-6		STUDENT'S No.	BOTANY 4-5-6	
	Total Test Score	Total Final Grade		Total Test Score	Total Final Grade
1	253	239	28	207	234
2	217	217	29	183	204
3	209	222	30	202	221
4	211	248	31	248	262
5	203	231	32	209	203
6	233	259	33	184	201
7	190	220	34	215	207
8	229	250	35	189	203
9	174	208	36	207	218
10	250	246	37	159	184
11	220	249	38	248	247
12	202	225	39	162	202
13	191	215	40	124	180
14	197	228	41	280	269
15	202	228	42	201	214
16	175	205	43	161	190
17	233	235	44	187	191
18	270	278	45	194	224
19	185	209	46	190	201
20	216	232	47	208	222
21	186	212	48	216	216
22	208	225	49	226	241
23	161	201	50	187	190
24	149	207	51	178	188
25	198	236	52	216	210
26	266	270	53	216	253
27	269	280	54	207	228

$$r \text{ (validity)} = .87 \pm .02.$$

cient of correlation between these two measures is $.87 \pm .02$. It is apparent, therefore, that the botany test may be considered as measuring quite significantly what the student has achieved in General Botany 4-5-6, inasmuch as the instructor's grade is a valid index of this achievement.

The reliability of the botany test (each part and the whole) as determined by "splitting" it into random halves, and the reliability of the whole examination and its parts as estimated by the Spearman-Brown formula:

$$r = \frac{2 r_{\frac{11}{22}}}{1 + r_{\frac{11}{22}}}$$

are given in Table XII. From this it is observed that the reliability of the botany test is $.93 \pm .01$ (for the data in the computation, see Table 35). The scores attained by the same fifty-four students on the composite examination (the total original examination from which the botany test was selected) and their corresponding scores on the botany test are given in Table 36. The coefficient of correlation between these two measures is $.89 \pm .02$. The scores of fifty-four students on the botany test and the corresponding scores attained on the items of the composite test not incorporated into the botany test are given in Table 37. The coefficient of correlation between these two measures is $.67 \pm .05$.

TABLE XII

RELIABILITIES OF TRUE-FALSE AND COMPLETION TESTS IN GENERAL BOTANY 4-5-6

TEST	$r_{\frac{11}{22}}$	SP.-BR. r_{11}
True-false	.77	.87 $\pm$.02
Completion, Botany 4	.81	.90 $\pm$.02
Completion, Botany 5	.70	.82 $\pm$.03
Completion, Botany 6	.85	.92 $\pm$.01
Whole test	.87	.93 $\pm$.01

With a validity coefficient of $.87 \pm .02$ and a reliability coefficient of $.93 \pm .01$, the botany test may be used with considerable confidence as a measuring instrument.

The Findings.—In determining the achievement of the student in a course in elementary botany, it is obviously desirable to have some

measure of the amount of botanical knowledge that he possesses at the time of his entrance to the course. Accordingly, the botany test was administered to all students entering the course in the fall quarter of 1927-1928. The test was given at the second meeting of the class for laboratory work. This made possible the use of two hours for taking the test. Table XIII gives the distribution of the scores of 288 students on the botany test, grouped according to the college in which they were enrolled. The median score for students in the College of Agriculture was 7.7; for students in the College of Forestry, 3.9; for students plan-

TABLE XIII

DISTRIBUTION OF SCORES ON BOTANY TEST OF STUDENTS BEGINNING BOTANY,
FALL QUARTER, 1927

SCORES	COLLEGE					TOTAL
	Agri- culture	Forestry	Business Admin.*	Nursing	S.L.A.	
0- 2	19	29	19	11	39	117
3- 5	8	10	5	4	17	44
6- 8	7	11	5	4	14	41
9-11	10	6	3	5	10	34
12-14	4		1	1	8	14
15-17	4	1		1	2	8
18-20	5	3		3	1	12
21-23	1	2			1	4
24-26	1	2			2	5
27-29	2				1	3
30-32					1	1
33-35	1					1
36-38						
39-41				1	1	2
42-44						
45-47					1	1
88					1	1
N	62	64	33	30	99	288
Q ₁	2.4	1.6	1.3	2.0	1.9	1.8
Md.	7.7	3.9	2.6	6.0	4.8	4.8
Q ₃	13.9	8.5	6.5	11.1	10.3	10.2

* In this and succeeding tables, the pre-business is the specific course to which this refers.

ning to enter the School of Business Administration, 2.6; for students in the School of Nursing, 6; and for students in the College of Science, Literature, and the Arts, 4.8. The median score for the entire population was 4.8. As measured by this test, then, the botanical knowledge of students entering the course in elementary botany is apparently negligible. To find out if the character of the previous high school preparation in science had any effect on the scores attained on the botany test, the median scores were computed for those students who had taken biological science—biology or botany; for those who had taken physical science—physics or chemistry; and for those who had taken botany. The median scores for these respective groups were 7.3, 2.6, and 9.7. The distribution of scores is given in Table XIV. Whereas those students with previous preparation in biological science, and more especially

TABLE XIV

DISTRIBUTION OF SCORES ON BOTANY TEST OF STUDENTS BEGINNING BOTANY WITH DIFFERENT HIGH SCHOOL PREPARATION IN SCIENCE, FALL QUARTER, 1927

SCORES	BIOLOGICAL SCIENCE	PHYSICAL SCIENCE	BOTANY
0- 2	46	66	18
3- 5	26	20	6
6- 8	25	13	7
9-11	26	5	11
12-14	11	4	7
15-17	7	1	2
18-20	8	3	5
21-23	3	1	
24-26	5		4
27-29	3		3
30-32	1		
33-35			
36-38	1		1
39-41	2		2
42-44			
45-47	1		
83	1		1
N	166	113	67
Q ₁	2.7	1.3	2.8
Md.	7.3	2.6	9.7
Q ₃	12.4	5.8	16.8

when botany was the biological science taken, show a superiority when their median score is compared with that of those students with previous preparation in the physical sciences, nevertheless their botanical knowledge as revealed by this test would seem to be very limited. Whether the character of previous preparation in science is significant in the ultimate achievement in general botany is discussed in the subsequent chapter.

THE EXTENT OF RETENTION OF BOTANICAL INFORMATION

The botany test, previously described, was administered to students in certain sequent courses in the College of Agriculture and Forestry, where a double period was given to it during the first week of the fall quarter, 1927. The courses in which the test was given were: Forest Mensuration, Silvics, General Agricultural Biochemistry, Phytochemistry, Soils, Fruit Growing, Principles of Genetics, Plant Pathology, and Farm Crops. By giving this test in such a diversity of courses it was hoped to secure records for the maximum number of students possible. More especially, the records for those students who had taken General Botany 4-5-6 during the previous year were desired, since for these there were available scores on this test, which had been attained at the time of completing the elementary botany course. The conditions under which the examination was given were made as uniform as possible. The purpose of giving the examination was explained and the general directions were: "The aim of this examination is to give you an opportunity to show what you have retained from your previous contact with botany. Read the directions for each part carefully and be sure you understand what you are to do before you begin." In all, 128 students took the test. The scholastic records of these students were looked up in the registrar's office to find out when each had taken the course in elementary botany and the grade that he had received. Of the total number, some had taken the course in elementary botany elsewhere, while others had not yet taken the course. As a result the grades of three groups of students were obtained, each restricted in number. One group of forty-two students had taken elementary botany in 1926-1927; another, twenty-nine in number, had taken elementary botany in 1925-1926; and the third, twenty-two in number, had taken it in 1924-1925. There had elapsed, then, three, fifteen, and twenty-seven months, respectively, for these groups from the time the course in elementary botany

was completed until the botany test was taken. Only those students were considered who had taken the course in elementary botany at the University of Minnesota.

The chief concern in this discussion is with the group of students who had taken elementary botany in 1926-1927, for, as previously mentioned, there were available for these students the scores made on that part of the test when any particular quarter's work had been completed. Of this group of forty-two students, twenty-nine had completed Botany 4-5-6 and all had completed Botany 4-5. Of this latter group thirteen had elected one course from Elementary Plant Physiology, Elementary Ecology, or Taxonomy of Flowering Plants in lieu of Botany 6.

The scores of twenty-four students on the immediate recall and delayed recall tests in General Botany 4-5-6 are given in Table XV (the scores of five of the group of twenty-nine students who had completed General Botany 4-5-6 were not incorporated in these data, since there was evidence that they had not exerted their best efforts in the latter part of the examination). The respective scores are given for the true-false test, Botany 4-5-6; the completion test, Botany 4; the completion test, Botany 5; the completion test, Botany 6; and the entire test, Botany 4-5-6. The mean score, standard deviation, and probable error of the mean are given for the immediate and delayed recall scores for each part of the test and for the test as a whole. The means of the total scores and their standard deviations for this group of twenty-four students, attained on the immediate recall and delayed recall tests were 207.4 ± 29.4 and 117.3 ± 46.6 , respectively. The loss in retention in per cent was 43.4. Figure 5³ shows the scores of these twenty-four students on the immediate recall and delayed recall tests for the true-false test (Botany 4-5-6), the completion test (Botany 4), the completion test (Botany 5), and the completion test (Botany 6). Failure to return to the University or absence on the day on which the examination was given had depleted the ranks of students for whom records on the immediate recall tests were available from fifty-four to twenty-four. However, in order to secure some basis for determining whether the results secured are typical or atypical, a comparison has been made between the group which took both the immediate and delayed recall tests and the group which took only the immediate recall test. The

³ The delayed recall test was given three months after completion of the course. Twenty-four students took the test.

TABLE XV

SCORES ON IMMEDIATE RECALL AND DELAYED RECALL TESTS OF STUDENTS IN GENERAL BOTANY 4-5-6, 1926-1927

STUDENT'S No.	BOTANY 4-5-6 TRUE-FALSE TEST			BOTANY 4 COMPLETION TEST			BOTANY 5 COMPLETION TEST			BOTANY 6 COMPLETION TEST			BOTANY 4-5-6 TOTAL SCORE		
	Immediate Recall Score	Delayed Recall Score	Score*	Immediate Recall Score	Delayed Recall Score†	Score†	Immediate Recall Score	Delayed Recall Score†	Score†	Immediate Recall Score	Delayed Recall Score†	Score†	Immediate Recall Score	Delayed Recall Score	Score
1	109	105		61	42		50	42		50	46		270		235
2	110	89		61	55		49	46		49	37		269		227
3	91	59		66	46		50	40		46	36		253		181
4	95	38		59	25		37	33		42	30		233		126
5	84	65		53	32		46	27		50	37		233		161
6	77	45		60	32		42	15		50	10		229		102
7	81	37		51	27		49	22		39	14		220		100
8	78	46		55	36		36	23		47	26		216		131
9	85	40		40	27		46	27		40	28		211		122
10	75	51		47	25		43	16		44	12		209		104
11	76	35		42	22		42	14		48	7		208		78
12	76	66		51	27		38	26		42	21		207		140
13	81	66		47	28		30	13		45	28		203		135
14	77	39		44	25		46	19		35	13		202		96
15	69	31		49	22		41	15		39	18		198		86
16	74	55		50	25		39	18		34	17		197		115
17	74	30		45	15		43	15		29	7		191		67
18	59	54		52	25		35	15		44	29		190		123
19	59	18		46	22		42	26		39	39		186		105
20	70	38		39	22		36	29		40	26		185		115
21	57	15		48	22		37	16		41	5		183		58
22	66	28		38	16		38	18		33	11		175		73
23	47	39		37	26		46	20		31	21		161		106
24	49	11		42	7		32	7		26	4		149		29
M	75.8	45.9		49.3	27.1		41.4	22.6		40.9	21.8		207.4		117.3
SD	±15.4	±21.5		±7.8	±9.8		±5.5	±9.6		±6.7	±11.8		±29.4		±46.6
PE _M	± 2.1	± 2.9		±1.07	±1.3		±.75	±1.32		±.9	± 1.6		± 4.04		± 6.4

* Interval—nine months.

† Interval—six months.

‡ Interval—three months.

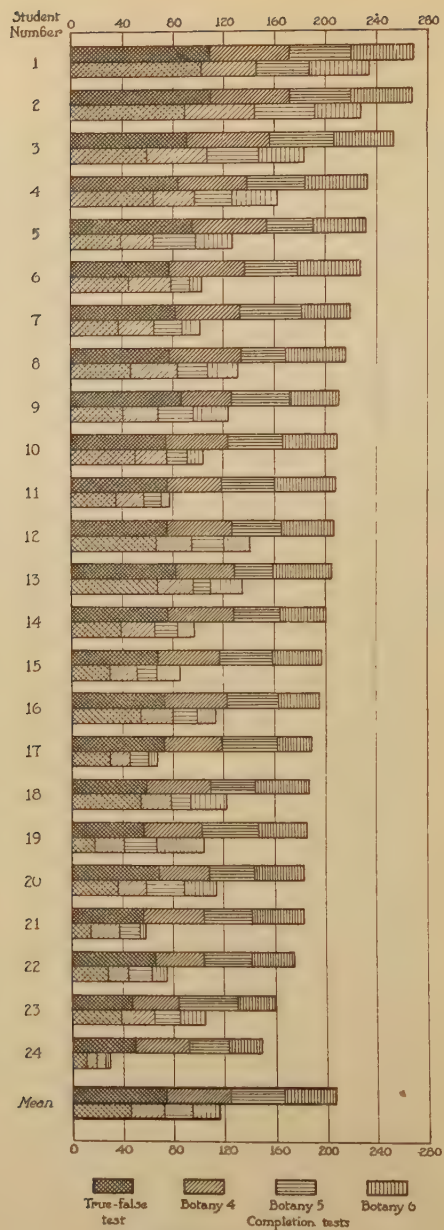


FIG. 5.—IMMEDIATE RECALL AND DELAYED RECALL SCORES ON GENERAL BOTANY 4-5-6 TEST

honor point ratios and scores on the immediate recall tests for the group of twenty-five students who did not take the delayed recall tests are given in Table XVI. The honor point ratios of the group of twenty-four students who took both the immediate and delayed recall tests are given in Table XXV. A comparison of the immediate recall test scores, honor point ratios, and percentile rank ratings on three intelligence tests (for

TABLE XVI

HONOR POINT RATIOS AND SCORES ON IMMEDIATE RECALL TESTS OF STUDENTS IN
GENERAL BOTANY 4-5-6 WHO DID NOT TAKE THE DELAYED RECALL TESTS

STUDENT'S No.	HONOR POINT RATIO	BOTANY 4-5-6	BOTANY 4 COMPLE-	BOTANY 5 COMPLE-	BOTANY 6 COMPLE-	BOTANY 4-5-6 TOTAL SCORE
		TRUE-FALSE	TION	TION	TION	
		TEST SCORE	TEST SCORE	TEST SCORE	TEST SCORE	
1	.846	74	42	41	45	202
2	1.387	99	60	44	45	248
3	.822	71	52	41	45	209
4	.263	69	55	33	27	184
5	.795	91	41	41	42	215
6	1.129	72	45	37	35	189
7	1.156	67	53	44	43	207
8	.931	47	37	42	33	159
9	1.823	101	56	44	47	248
10	.611	39	55	39	29	162
11	.325	37	35	28	24	124
12	2.039	119	61	50	50	280
13	.704	79	41	41	40	201
14	.434	55	38	44	24	161
15	.422	38	58	43	48	187
16	.968	81	41	36	36	194
17	.561	58	53	37	42	190
18	.482	73	51	44	40	208
19	.863	72	52	45	47	216
20	1.543	100	48	43	35	226
21	.511	75	48	33	31	187
22	1.115	44	58	43	33	178
23	.364	72	58	44	42	216
24	1.800	92	46	38	40	216
25	.920	83	46	39	39	207
M	.878	72.3	49.2	40.6	38.5	200.5

TABLE XVII

COMPARISON OF IMMEDIATE RECALL TEST SCORES, HONOR POINT RATIOS, AND INTELLIGENCE TEST RATINGS OF TWO GROUPS OF STUDENTS IN GENERAL BOTANY 4-5-6*

	GROUP 1	GROUP 2	GROUPS 1 & 2
	Number		
	24	25	49
Mean score, Botany 4-5-6†	207.4	200.5	203.9
σ_{dis}	29.65**	31.60**	30.66
σ_M	6.07	6.32	4.38
Mean honor point ratio ‡.....	1.264	.878	1.067
σ_{dis}	.465	.540	.503
σ_M	.095	.110	.072
Mean percentile rank (intelligence test)	59.5††	51.6‡‡	.....

* One group later took the delayed recall test.

$$\dagger \frac{D_i}{\sigma_{(diff)}} = .79.$$

$$\ddagger \frac{D_i}{\sigma_{(diff)}} = 2.66.$$

** Computed from the mean of the combined distribution (Groups 1 and 2).

†† Computed for twenty cases.

‡‡ Computed for seventeen cases.

as many of the members of the groups for whom these were available) for the two groups in question is given in Table XVII. The respective mean scores with standard deviations and honor point ratios with standard deviations for the group of twenty-four students, who took both the immediate recall and delayed recall tests, and the group of twenty-five students, who took only the immediate recall tests were 207.4 ± 29.65 (mean scores); $1.264 \pm .465$ (honor point ratios) and 200.5 ± 31.6 ; $.878 \pm .54$. The ratio, $\frac{D}{\sigma_{(diff)}}$, for the mean scores is .79; for the honor point ratios, 2.66. Whereas the difference between the mean scores is not statistically significant, the difference in honor point ratios approaches a significant difference, i.e., the chances are 9,922 in 10,000 that the true difference between the means of the two groups is greater than zero. The implication from this comparison is that the mean score on the delayed recall tests— 117.3 ± 46.6 for the group of twenty-four

students—would, if anything, have been lowered had the twenty-five students returned to the University or been present to take the delayed recall tests, so that their scores might have been incorporated with those considered in this discussion. However, this study is not concerned with those students who do not return to the University but rather with those who have taken the elementary course in botany and are pursuing the sequent courses for which it is a prerequisite.

Table XVIII gives the scores of thirty-six students on the immediate recall and delayed recall tests in General Botany 4-5. The respective scores are given for the true-false test (Botany 4-5), the completion test (Botany 4), the completion test (Botany 5), and the entire test (Botany 4-5). The mean score, standard deviation of the mean, and probable error of the mean are given for each part of the test and for the test as a whole. The means of the total scores and their standard deviations for this group of thirty-six students on the immediate and delayed recall tests were 141.8 ± 19.9 and 74.1 ± 29.1 , respectively. The loss in retention in per cent was 47.8.

Table XIX gives the honor point ratios and scores of students on the immediate recall tests who did not take the delayed recall tests in General Botany 4-5. Comparisons of the mean score on the immediate recall test and the mean honor point ratio of this group with those of the thirty-six students above discussed give 140 and .906, respectively, for the former; and 141.8 and 1.292, respectively, for the latter. The effect, if any, had these students taken the delayed recall test (thus permitting the incorporation of their scores with those of the group of thirty-six students) would apparently have been in the direction of lowering rather than raising the mean score on the delayed recall test.

Table XX gives the scores of forty-two students on the immediate and delayed recall tests, limited to the true-false test (Botany 4-5) and the completion test (Botany 4). The purpose of educing these data was to secure a basis for determining whether the relation between the immediate recall and delayed recall score remained as constant in the first half of the test as in the last (in a certain sense a measure of reliability). This determination seemed desirable inasmuch as in a lengthy examination of this character, the student might vary in the distribution of his effort. The mean scores with their standard deviations for this group of forty-two students on the immediate and delayed recall tests (true-false test, Botany 4-5 and completion test, Botany 4) were 101.3 ± 18.03

TABLE XVIII
SCORES ON IMMEDIATE RECALL AND DELAYED RECALL TESTS OF STUDENTS IN GENERAL BOTANY 4-5

STUDENT'S No.	BOTANY 4-5 TRUE-FALSE TEST			BOTANY 4 COMPLETION TEST			BOTANY 5 COMPLETION TEST			BOTANY 4-5 TOTAL SCORE		
	Immediate Recall Score	Delayed Recall Score	Score	Immediate Recall Score	Delayed Recall Score*	Score†	Immediate Recall Score	Delayed Recall Score†	Score†	Immediate Recall Score	Delayed Recall Score	Score
1	75	66		61	42		50	42		186		150
2	73	56		61	55		49	46		183		157
3	64	48		66	46		50	40		180		134
4	75	19		54	25		43	14		172		58
5	66	21		59	25		37	33		162		79
6	57	30		60	32		42	15		159		77
7	55	50		53	32		46	27		154		109
8	54	22		51	27		49	22		154		71
9	56	41		51	23		45	27		152		91
10	57	28		48	29		44	9		149		66
11	57	44		51	26		40	19		148		89
12	59	37		50	25		39	18		148		80
13	54	34		53	15		40	7		147		56
14	56	26		55	36		36	23		147		85
15	49	40		60	40		37	23		146		103
16	60	32		40	27		46	27		146		86
17	59	21		43	25		44	10		146		56
18	58	25		45	15		43	15		146		55
19	56	21		47	11		42	17		145		49
20	50	15		47	15		45	14		142		44

* Interval—nine months.

† Interval—six months.

TABLE XVIII—Continued

SCORES ON IMMEDIATE RECALL AND DELAYED RECALL TESTS OF STUDENTS IN GENERAL BOTANY 4-5

STUDENT'S No.	BOTANY 4-5 TRUE-FALSE TEST			BOTANY 4 COMPLETION TEST			BOTANY 5 COMPLETION TEST			BOTANY 4-5 TOTAL SCORE	
	Immediate Recall Score	Delayed Recall Score	Delayed Recall Score*	Immediate Recall Score	Delayed Recall Score	Delayed Recall Score*	Immediate Recall Score	Delayed Recall Score†	Delayed Recall Score	Immediate Recall Score	Delayed Recall Score
21	51	35	25	47	43	16	43	16	141	76	
22	49	24	25	44	46	19	46	19	139	68	
23	45	13	22	46	42	26	42	26	133	61	
24	43	35	27	51	38	26	38	26	132	88	
25	47	12	22	48	37	16	37	16	132	50	
26	41	19	22	49	41	15	41	15	131	56	
27	54	49	28	47	30	13	30	13	131	90	
28	46	16	22	42	42	14	42	14	130	52	
29	40	38	25	52	35	15	35	15	127	78	
30	47	23	22	39	36	29	36	29	122	74	
31	45	24	16	38	88	18	88	18	121	58	
32	36	22	26	37	46	20	46	20	119	68	
33	44	14	7	42	32	7	32	7	118	28	
34	42	21	11	36	37	14	37	14	115	46	
35	45	32	10	30	31	15	31	15	106	57	
36	32	13	4	30	33	6	33	6	95	23	
M	52.7	29.6	24.6	48.1	40.9	19.9	40.9	19.9	141.8	74.1	
SD	±9.7	±13.01	±10.4	±8.4	±5.2	±9.4	±5.2	±9.4	±19.9	±29.1	
PE _M	±1.08	±1.46	±1.16	±.94	±.59	±1.04	±.59	±1.04	±2.23	±3.27	

* Interval—nine months.

† Interval—six months.

TABLE XIX

HONOR POINT RATIOS AND SCORES ON IMMEDIATE RECALL TESTS OF STUDENTS IN
GENERAL BOTANY 4-5 WHO DID NOT TAKE THE DELAYED RECALL TESTS

STUDENT'S No.	HONOR POINT RATIO	BOTANY 4-5-6 TRUE-FALSE TEST	BOTANY 4 COMPLETION TEST	BOTANY 5 COMPLETION TEST	BOTANY 4-5 TOTAL SCORE
1	.791	50	52	44	146
2	.846	61	67	49	177
3	.700	35	57	45	137
4	1.131	64	40	34	138
5	.824	36	65	48	149
6	1.516	70	40	38	148
7	.454	54	56	50	160
8	.312	59	42	32	133
9	.979	48	55	36	139
10	2.353	58	34	34	126
11	.272	50	56	49	155
12	1.020	69	42	35	146
13	.76	47	42	33	122
14	.666	51	36	29	116
15	.97	41	41	26	108
M	.906	52.9	48.3	38.8	140

and 55.3 ± 23.5 , respectively. The loss in retention in per cent was 45.4, which is intermediate between those of 47.8 and 43.4, previously reported. Therefore, it would seem that since the ratio between the immediate recall and delayed recall scores remained fairly constant throughout the examination, it may be inferred that the effort of the student was distributed quite uniformly.

Table XXI summarizes the facts concerning the retention of the students who took elementary botany in 1926-1927. It is observed that the loss in retention on the true-false type of responses is approximately 6 per cent less than that on the completion type. This would seem to bear out the assertion that although the student may not have the specific information at his immediate command, the associations are present though dormant until awakened (granted that the method of scoring used, i.e., "rights" minus "wrongs," takes care of the guessing element). By comparing the loss on the completion type of items, it is observed that the losses in retention are 45, 45.4, and 46.7 for General Botany 4, 5, and 6, respectively. The intervals between the immediate and

TABLE XX

SCORES ON IMMEDIATE RECALL AND DELAYED RECALL TESTS IN GENERAL BOTANY 4-5

(Test Limited to True-False Test, Botany 4-5, and Completion Test, Botany 4)

STUDENT'S No.	BOTANY 4-5 TRUE-FALSE TEST		BOTANY 4 COMPLETION TEST		BOTANY 4-5-6 TOTAL SCORE	
	Immediate	Delayed	Immediate	Delayed	Immediate	Delayed
	Recall Score	Recall Score	Recall Score	Recall Score*	Recall Score	Recall Score
1	77	61	59	57	136	118
2	75	66	61	42	136	108
3	73	56	61	55	134	111
4	64	48	66	46	130	94
5	68	51	62	31	130	82
6	75	19	54	25	129	44
7	66	21	59	25	125	46
8	57	30	60	32	117	62
9	62	40	50	22	112	62
10	56	26	55	36	111	62
11	59	37	50	25	109	62
12	49	40	60	40	109	80
13	55	50	53	32	108	82
14	57	44	51	26	108	70
15	54	34	53	15	107	49
16	56	41	51	23	107	64
17	54	22	51	27	105	49
18	57	28	48	29	105	57
19	58	25	45	15	103	40
20	56	21	47	11	103	32
21	59	21	43	25	102	46
22	54	49	47	28	101	77
23	60	32	40	27	100	59
24	51	35	47	25	98	60
25	50	15	47	15	97	30
26	47	12	48	22	95	34
27	43	35	51	27	94	62
28	54	37	40	22	94	59
29	49	24	44	25	93	49
30	40	38	52	25	92	63
31	45	13	46	22	91	35
32	41	19	49	22	90	41
33	46	16	42	22	88	38
34	44	14	42	7	86	21

* Interval—nine months.

TABLE XX—*Continued*

SCORES ON IMMEDIATE RECALL AND DELAYED RECALL TESTS IN GENERAL BOTANY 4-5
(Test Limited to True-False Test, Botany 4-5, and Completion Test, Botany 4)

STUDENT'S No.	BOTANY 4-5 TRUE-FALSE TEST		BOTANY 4 COMPLETION TEST		BOTANY 4-5-6 TOTAL SCORE	
	Immediate Recall Score	Delayed Recall Score	Immediate Recall Score	Delayed Recall Score*	Immediate Recall Score	Delayed Recall Score
35	47	23	39	22	86	45
36	42	21	42	15	84	36
37	45	24	38	16	83	40
38	42	21	36	11	78	32
39	36	22	37	26	73	48
40	45	32	30	10	75	42
41	32	5	36	11	68	16
42	32	13	30	4	62	17
M	53.1	30.5	48.2	24.8	101.3	55.3
SD	± 10.9	± 13.4	± 8.1	± 11.2	± 18.03	± 23.5
PE _M	± 1.1	± 1.4	$\pm .84$	± 1.16	± 1.97	± 2.44

* Interval—nine months.

delayed recall tests for these portions of the test are nine, six, and three months, respectively. The material acquired more recently, therefore, does not seem to be retained to any greater extent (even slightly less) than that acquired at an earlier time. This apparently is due to the nature of the content, as will be pointed out later when a qualitative analysis of the material retained is discussed.

Just how much of the botanical information represented in the mean score on the immediate recall test is accumulated during the regular progression of the course and how much is the result of "cramming" for the final examination is not definitely known. As a means of affording some assistance in answering this question the data presented in Table XXII may be valuable. This table gives the scores of ninety-two students in the College of Agriculture and Forestry on that part of the botany test which covers the content of Botany 4-5. The test was given at the time of the completion of Botany 4-5, at the end of the winter quarter, 1928. The students were unaware that the test was to be administered. It is believed that the students gave their best effort for

TABLE XXI

MEAN OF IMMEDIATE RECALL AND DELAYED RECALL SCORES, AND PERCENTAGE OF LOSS IN RETENTION ON EACH PART AND ON THE WHOLE TEST IN GENERAL BOTANY 4-5-6

No. of STUDENTS	BOTANY 4-5-6 TRUE-FALSE TEST				BOTANY 4 COMPLETION TEST				BOTANY 5 COMPLETION TEST				BOTANY 6 COMPLETION TEST				BOTANY 4-5-6 TOTAL SCORE			
	Imme- diate Re- call		De- layed Re- call		Imme- diate Re- call		De- layed Re- call		Imme- diate Re- call		De- layed Re- call		Imme- diate Re- call		De- layed Re- call		Imme- diate Re- call		De- layed Re- call	
	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent	Score	Cent
24	75.8	45.9	49.3	39.4	49.3	45.0	27.1	45.0	41.4	22.6	45.4	40.9	21.8	46.7	207.4	117.3	43.4			
36*	52.7	29.6	43.6	43.6	48.1	48.8	24.6	48.8	40.9	19.9	51.3	.....	.....	.....	141.8	74.1	47.8			
42†	53.1	30.5	42.5	42.5	48.2	48.6	24.8	48.6	.....	.....	.....	.....	.....	.....	101.3	55.3	45.4			

* Scores on Botany 4-5.

† Scores on Botany 4-5, true-false, and Botany 4, completion tests.

they did not know but that their score on the test might have a bearing on their final grade. The test was given several days before the final examination so the assumption is that the students had not as yet made special preparation. The mean score on the test for this group of ninety-two students was 90.5 as compared with that of 141.8 (see Table XVIII) for the group of thirty-six students who had taken the same test the year previous, when it constituted a part of their final examination. There is this difference, viz., that the group for whom the test constituted a part of their final examination took that part of the test covering the content of Botany 4 at the end of the fall quarter and that part of the test covering the content of Botany 5 at the end of the winter quarter. Therefore, a better comparison would perhaps be between the mean scores of the groups on that part of the test covering the content of Botany 5. The mean scores on the completion test (Botany 5) were 40.9 and 23.9 for the groups of thirty-six and ninety-two students, respectively. The mean percentile rank in intelligence for twenty-six of the group of thirty-six was 55.7 and for sixty-six of the group of ninety-two was 48.2, which would indicate that the smaller group was more select. However, these data show that a considerable part of the botanical information represented in the mean score on the immediate recall test may be due, to some extent at least, to cramming (36.2 per cent, when the difference between the mean, 141.8, attained by the group of thirty-six students on the Botany 4-5 test is compared with 90.5, which is the mean that was attained by the group of ninety-two students; or 41.6 per cent when the difference between the respective means (40.9 and 23.9) on the completion test (Botany 5) is considered. The relationship which this cramming may bear to retention cannot be determined from the data at hand. There may be some implication in the fact that the mean score (90.5) of the group of ninety-two students on the test (Botany 4-5) is closer to the mean score (74.1) of the group of thirty-six students on the delayed recall test (Botany 4-5) than it is to the mean score (141.8) attained by the latter group on the immediate recall test (Botany 4-5). If the same test (Botany 4-5) were given to this group of ninety-two students six months later, some pertinent data might be obtained that should help in answering this question.

Table XXIII gives the honor point ratios, the grades in General Botany 4-5-6, and scores on the botany test of the group of twenty-nine

TABLE XXII

SCORES ON IMMEDIATE RECALL TEST OF STUDENTS IN THE COLLEGE OF AGRICULTURE
AND FORESTRY WHO TOOK BOTANY 4-5

(Test Given at End of Winter Quarter, 1928, Unannounced)

STUDENT'S No.	BOTANY 4	BOTANY 5	BOTANY 4-5	BOTANY 4	BOTANY 5	BOTANY 4-5
	TRUE- FALSE TEST	TRUE- FALSE TEST	TOTAL TRUE- FALSE	COMPLETION TEST	COMPLETION TEST	TOTAL SCORE
1	29	37	66	55	39	160
2	31	35	66	49	35	150
3	25	28	53	51	38	142
4	17	38	55	47	34	136
5	28	30	58	46	30	134
6	18	31	49	50	35	134
7	25	36	61	36	34	161
8	15	26	41	49	40	130
9	21	36	57	48	23	128
10	19	30	49	43	34	126
11	17	36	53	37	33	123
12	23	23	46	37	36	119
13	19	21	40	51	27	118
14	21	27	48	39	31	118
15	18	34	52	36	30	118
16	21	30	51	42	23	116
17	18	27	45	34	36	115
18	14	32	46	37	31	114
19	16	34	50	31	31	112
20	23	23	46	34	31	111
21	21	20	41	37	32	110
22	21	26	47	28	35	110
23	15	31	46	34	29	109
24	23	25	48	27	33	108
25	9	29	38	38	31	107
26	15	30	45	37	24	106
27	5	16	21	50	34	105
28	14	25	39	34	32	105
29	18	30	48	28	28	104
30	12	33	45	31	27	103
31	14	28	42	41	20	103
32	17	20	37	36	29	102
33	12	26	38	37	26	101
34	12	29	41	32	28	101
35	16	20	36	34	31	100

TABLE XXII—*Continued*

SCORES ON IMMEDIATE RECALL TEST OF STUDENTS IN THE COLLEGE OF AGRICULTURE
AND FORESTRY WHO TOOK BOTANY 4-5

(Test Given at End of Winter Quarter, 1928, Unannounced)

STUDENT'S No.	BOTANY 4	BOTANY 5	BOTANY 4-5	BOTANY 4	BOTANY 5	BOTANY 4-5
	TRUE- FALSE TEST	TRUE- FALSE TEST	TRUE- FALSE TEST	COMPLETION TEST	COMPLETION TEST	TOTAL SCORE
36	23	28	51	30	20	101
37	25	22	47	31	23	101
38	19	25	44	28	28	100
39	15	27	42	37	19	98
40	16	23	39	33	24	96
41	11	17	28	39	28	95
42	16	16	32	36	27	95
43	13	29	42	32	20	94
44	7	31	38	29	26	93
45	11	23	34	36	23	93
46	13	21	34	34	24	92
47	15	24	39	25	27	91
48	15	18	33	31	26	90
49	1	16	17	33	40	90
50	11	19	30	34	23	87
51	19	17	36	36	15	87
52	17	26	43	16	26	85
53	2	33	35	22	27	84
54	3	36	39	17	26	82
55	13	18	31	30	21	82
56	9	29	38	24	20	82
57	2	19	21	34	25	80
58	10	19	29	25	26	80
59	8	21	29	29	22	80
60	5	23	28	31	16	75
61	8	31	39	19	18	76
62	10	14	24	25	25	74
63	12	24	36	10	27	73
64	20	12	32	32	9	73
65	10	20	30	22	21	73
66	19	18	37	20	16	73
67	16	15	31	24	18	73
68	11	13	24	32	16	72
69	10	18	28	33	9	70
70	17	18	35	20	15	70

TABLE XXII—*Concluded*

SCORES ON IMMEDIATE RECALL TEST OF STUDENTS IN THE COLLEGE OF AGRICULTURE
AND FORESTRY WHO TOOK BOTANY 4-5

(Test Given at End of Winter Quarter, 1928, Unannounced)

STUDENT'S No.	BOTANY 4 TRUE- FALSE TEST	BOTANY 5 TRUE- FALSE TEST	BOTANY 4-5 TOTAL TRUE- FALSE	BOTANY 4 COMPLETION TEST	BOTANY 5 COMPLETION TEST	BOTANY 4-5 TOTAL SCORE
71	9	24	33	10	27	70
72	8	17	25	31	13	69
73	12	17	29	22	17	68
74	12	12	24	17	27	68
75	1	23	24	30	12	66
76	9	12	21	26	18	65
77	19	8	27	31	7	65
78	13	9	22	26	16	64
79	5	17	22	31	10	63
80	3	8	11	30	21	62
81	6	10	16	23	22	61
82	7	9	16	16	29	61
83	15	4	19	20	20	59
84	3	20	23	18	18	59
85	10	26	36	14	5	55
86	5	11	16	19	14	49
87	10	6	16	18	14	48
88	6	18	24	12	10	46
89	3	7	10	24	12	46
90	4	5	9	18	12	39
91	5	4	9	17	10	36
92	5	8	13	11	9	33
M	13.5	22.2	35.7	30.8	23.9	90.5

students who took General Botany 4-5-6 in 1925-1926. The test was taken fifteen months after the completion of the course in elementary botany. There were no records for these students on the immediate recall test, so an accurate measurement of their retention is not possible. Some index of their botanical information at the time of completing the course is afforded by the grades received in General Botany 4-5-6. The correlation between the scores attained by this group of students on the botany test and the corresponding grades attained in General Botany 4-5-6 was $.81 \pm .05$. This would indicate that the

TABLE XXIII

HONOR POINT RATIOS, GRADES IN BOTANY, AND SCORES ON BOTANY TEST OF STUDENTS WHO TOOK GENERAL BOTANY 4-5-6,

1925-1926

(Test Taken Fifteen Months after Completion of Course)

[illegible]

student who had the most botanical information (as far as an instructor's grade is a valid criterion) at the time of completing the course retained the most—in so far as the botany test is valid—after an interval of fifteen months. The median score of this group of twenty-nine students was 53.

Table XXIV gives the honor point ratios, the grades in General Botany 4-5-6, and the scores on the botany test of the group of twenty-two students who took General Botany 4-5-6 in 1924-1925. The interval between the time of completion of the course and the time of taking the test was twenty-seven months. The median score of this group on the botany test was 49. The coefficient of correlation between botany grades and test scores was $75 \pm .06$. Table XXV gives the corresponding data for the group of twenty-four students, who took botany in 1926-1927. This is the same group previously discussed but these data have been compiled for comparison with the other groups. The median score on the botany test of this group was 110.5. The coefficient of correlation between botany grades and test scores was $.65 \pm .08$.

Table XXVI summarizes the data concerning the coefficient of correlations between the grades in General Botany 4-5-6 and scores on the botany test for the three groups discussed. From these it is observed that there appears to be a high relationship between the amount of botanical information possessed by the student at the time of completing the course in elementary botany and the amount possessed three, fifteen, and twenty-seven months later.

TABLE XXVI

COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN GRADES IN GENERAL BOTANY 4-5-6 AND SCORES ON BOTANY TEST OF THREE GROUPS

No. OF STUDENTS	BOTANY 4-5-6		ρ
	Year Taken	Months after Completion	
24	1926-1927	3	$.65 \pm .08$
29	1925-1926	15	$.81 \pm .05$
22	1924-1925	27	$.75 \pm .06$

As a basis for comparing the retention of botanical information of the three groups previously discussed, the data presented in Table

TABLE XXVII
COMPARISON OF SCORES ON BOTANY TEST AT VARIOUS INTERVALS AFTER COMPLETION OF GENERAL BOTANY 4-5-6

No. of STUDENTS	GENERAL BOTANY 4-5-6		Q ₁	Md.	Q ₃	MEAN* BOTANY GRADE	MEAN HONOR POINT RATIO	MEAN PERCENTILE RANK
	Year Taken	Months after Completion						
126	1927-1928	Beginning Botany	2.0	5.5	10.9	.....	.....	.....
24	1926-1927	0	188.0	205.0	224.5	2.65	1.264	58.2†
24	1926-1927	8	91.0	110.5	133.0	2.65	1.264	58.2
29	1925-1926	15	84.0	53.0	87.0	2.8	1.318	50.0†
22	1924-1925	27	84.0	49.0	71.0	2.83	1.418	57.6**

* Grade A = 1, B = 2, C = 3, D = 4, E = 5, F = 6.

† Based on nineteen cases.

** Based on eight cases.

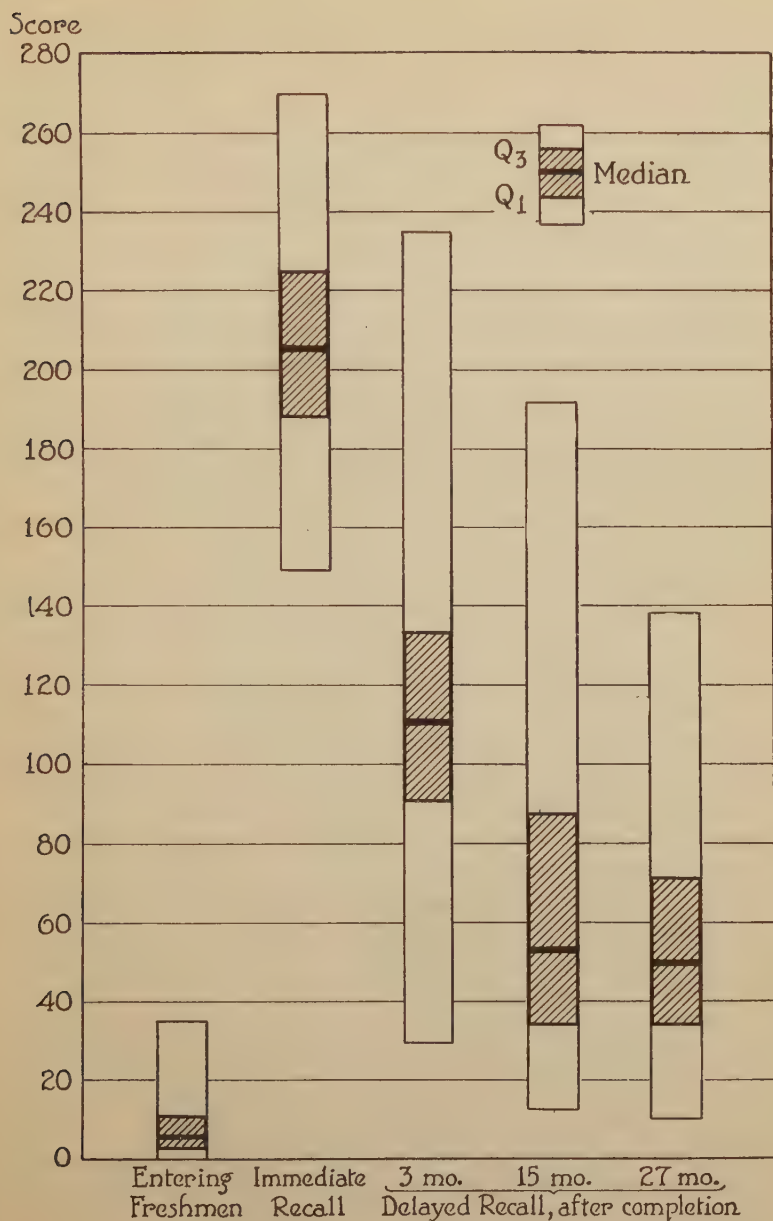


FIG. 6.—RANGE, INTERQUARTILE RANGES, AND MEDIAN SCORES ON GENERAL BOTANY 4-5-6 TEST OF STUDENTS AT VARIOUS INTERVALS AFTER COMPLETION OF GENERAL BOTANY 4-5-6

XXVII were compiled. The mean botany grade (computed from the weightings: A = 1, B = 2, C = 3, D = 4, E = 5, F = 6) for the group of twenty-four students who took General Botany 4-5-6 in 1926-1927 was 2.65; for the group of twenty-nine students who took General Botany 4-5-6 in 1925-1926 was 2.8; and for the group of students who took General Botany 4-5-6 in 1924-1925 was 2.83. The mean honor point ratios for these three groups were 1.264, 1.318, and 1.418, respectively. The respective mean percentile ranks in intelligence (for as many cases as these were available) were 58.2, 50, and 57.6. In so far as these are valid measures it would appear, therefore, that these three groups are fairly comparable. Within the limitations imposed by the number of cases and the validity of the technique employed in securing the data, a tentative generalization might be made that the median freshman entering the course in General Botany 4-5-6 attains a score of 5.5 on the botany test given; this score has been raised to 205 during the progression through the course; then three, fifteen, and twenty-seven months after completion of the course the median scores are represented by the measures 110.5, 53, and 49, respectively. These data are represented graphically in Figure 6. The percentage of loss in retention represented by the drop of the median score from 205 to 110.5 is 46.1; from 110.5 to 53, 52.04; and from 53 to 49, 7.5 (assuming that the groups are directly comparable). The rate of loss would, therefore, appear to be quite rapid during the three and fifteen months after completing the course, followed by a gradual decline afterwards.

Table XXVIII gives the percentile ranks in intelligence, based upon scores attained on three intelligence tests, viz., Moore's Completion, Opposites-Test, and vocabulary B, given to entering freshmen at the University of Minnesota. The corresponding scores on the immediate recall and delayed recall tests in General Botany 4-5 are also given. Records were available for only twenty-six of the forty-two individuals who took the immediate recall and delayed recall tests. The coefficients of correlation between the percentile ranks in intelligence and the scores attained on the immediate recall and delayed recall tests in General Botany 4-5 are given in Table XXIX. These coefficients were $.21 \pm .13$ and $.27 \pm .12$ between percentile rank ratings and scores on the immediate recall and delayed recall tests, respectively. With probable errors as large as these any trustworthy conclusion is impossible.

TABLE XXVIII

PERCENTILE RANKS IN INTELLIGENCE AND CORRESPONDING SCORES ON THE IMMEDIATE
RECALL AND DELAYED RECALL TESTS IN GENERAL BOTANY 4-5

STUDENT'S No.	PERCENTILE RANK	BOTANY 4-5	
		Immediate Recall Score	Delayed Recall Score
1	100	180	134
2	92	159	77
3	89	147	56
4	87	146	103
5	86	122	74
6	82	131	56
7	81	132	88
8	79	183	157
9	77	154	109
10	73	141	76
11	69	172	58
12	54	133	61
13	46	139	68
14	46	146	56
15	44	148	89
16	38	146	55
17	37	186	150
18	37	95	23
19	36	119	68
20	35	127	78
21	35	147	85
22	34	130	52
23	31	162	79
24	18	148	80
25	18	149	66
26	3	115	46

TABLE XXIX

COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN PERCENTILE
RANKS IN INTELLIGENCE AND SCORES ON THE IMMEDIATE RECALL AND
DELAYED RECALL TESTS IN GENERAL BOTANY 4-5

PERCENTILE RANK	IMMEDIATE RECALL SCORE	DELAYED RECALL SCORE
	$\rho = .21 \pm .13$	$\rho = .27 \pm .12$
N	26	26

THE RELATIONSHIP BETWEEN THE AMOUNT OF BOTANICAL INFORMATION
RETAINED AND THE INITIAL AMOUNT POSSESSED

The coefficients of correlation presented in Table XXVI indicate a considerable interdependence between the initial amount of botanical information possessed by the student at the time of completing the course in General Botany 4-5-6 and the amount retained at the end of certain intervals of time. These coefficients do not, however, answer the question whether the individual who had the most botanical information at the time of completing the course in elementary botany retains relatively the most after certain intervals of time. A formula developed by Harris⁴ for dealing with certain biological data may assist in answering this question. The formula is:

$$r_{xz} = \frac{r_{xy} - \frac{V_x}{V_y}}{\sqrt{1 - r_{xy}^2 + \left(r_{xy} - \frac{V_x}{V_y}\right)^2}}$$

From the data given in Table XVIII we have the following values: x = score on the immediate recall test; y = score on the delayed recall test; and z = the deviation of the y of any individual from its most probable value. The problem is to determine whether the relative value of y changes from the lower to the higher grades of x .

$$M_x = 141.8$$

$$SD_x = 19.9$$

$$V_x = \frac{100 SD}{M_x} = 14.034$$

$$r_{xy} = .754 \pm .048$$

$$M_y = 74.1$$

$$SD_y = 29.1$$

$$V_y = \frac{100 SD}{M_y} = 39.27$$

$$\frac{V_x}{V_y} = .3574$$

$$r_{xz} = .517 \pm .08$$

From the high relation denoted by the value, $r_{xy} = .754 \pm .048$, and the marked or substantial relation denoted by the value, $r_{xz} = .517 \pm .08$, it appears that as far as these thirty-six individuals in question are concerned, those students who have the most botanical information as measured by the botany test at the time of completing Botany 4-5 are

⁴ Harris, J. Arthur. "The Correlation between a Variable and the Deviation of a Dependent Variable from Its Probable Value." *Biometrika*, VI: 438-443.

likely to retain not only absolutely more but relatively more of this information after an interval of six months.

Similarly, applying the formula to the data given in Table XV we have:

$$\begin{array}{ll}
 M_x = 207.4 & M_y = 117.3 \\
 SD_x = 29.4 & SD_y = 46.6 \\
 V_x = 14.17 & V_y = 39.73 \\
 r_{xy} = .84 \pm .04 & \frac{V_x}{V_y} = .357 \\
 & r_{xz} = .665 \pm .07
 \end{array}$$

It appears, then, that the same conclusion drawn concerning the preceding group holds true for this group as well. That is, from the high relation denoted by the value, $r_{xy} = .84 \pm .04$, and the marked or substantial relation denoted by the value, $r_{xz} = .665 \pm .07$, it is apparent that for this group of twenty-four students, those students who have the most botanical information as measured by the botany test at the time of completing Botany 4-5-6, are likely to retain not only absolutely more but relatively more of this information after an interval of three months.

THE NATURE OF THE BOTANICAL MATERIAL RETAINED

Whereas the foregoing data have revealed quantitatively the percentages of loss in retention after the lapse of various intervals of time, it appeared desirable from the standpoint of the problem under investigation to determine if there were qualitative differences in the nature of the material retained. Accordingly, there was computed the number of errors committed on each of the 298 items of the botany test by each of the three groups of students, viz., (1) those students who completed General Botany 4-5-6 in 1926-1927 (errors computed for both the immediate and delayed recall tests); (2) those students who completed General Botany 4-5-6 in 1925-1926; and (3) those students who completed General Botany 4-5-6 in 1924-1925. In addition the errors were recorded for the group of students beginning General Botany 4-5-6 in 1927-1928. The items comprising the botany test were assigned to the several botanical categories discussed in Chapter II. That is, items such as, "The cell plate is formed during the prophase" and "A typical plant cell consists of a mass of living material known

as *protoplasm* and is usually surrounded by a wall of cellulose" were assigned to the botanical category, cytology. Items such as, "The xylem regions of neighboring vascular bundles are separated from each other by *medullary rays*" and "The ground tissue of corn stem consists largely of collenchyma" were assigned to the botanical category, histology. Items such as, "The structure of the sporophyte of the common moss is not so complex as that of *Marchantia*" and "In pine the *gametophytic* generation is a parasite upon the *sporophyte*" were assigned to the botanical category, comparative morphology. Similarly, the other items were distributed in the several botanical categories. The results of this analysis are given in Table 38 which shows the numbers of correct and incorrect responses and the percentage of correct responses to the 298 test items for each of the groups considered.

From the number of correct responses made to the several items of the test comprising any given botanical category, and upon the basis of the total number of correct responses possible, there was computed the percentage of correct responses to the test items classified in the several botanical categories. These data are given in Table XXX. Whereas there are limitations placed upon any comparisons that might be made of these percentages, since the numbers of items in the botanical categories are unequal and since the validity of the respective test items is not known, nevertheless there appears to be considerable variation in the nature of the material retained. Let the following assumptions be made:

1. The percentages of correct responses to the items comprising the several botanical categories, made by the group of students who took botany in 1926-1927, are typical of those that would have been made at the time of completing General Botany 4-5-6 by those groups which took General Botany 4-5-6 in 1925-1926 and 1924-1925.
2. The items of the test have been properly classified in the several botanical categories.
3. The opportunity of forgetting due to the greater number of items in certain categories is balanced by the necessity for retaining fewer items in the other categories.

Depending upon the validity of these assumptions these data are deduced from Table XXX.

Taking the percentages of correct responses made at the time of completing the course by the group of students who took General Botany

TABLE XXX
PERCENTAGE OF CORRECT RESPONSES TO TEST ITEMS CLASSIFIED IN THE SEVERAL BOTANICAL CATEGORIES

No. of STUDENTS	BOTANY 4-5-6		Comp. MORPH.	Hist.	Alg.	Cyt.	MORPH.		Myc.	Phys.	Bact.	Genet.
	Year Taken	Months after Completion					Fl. Pl.					
126	1927-1928	Entering Freshmen	1.9	4.4	2.4	2.9	10.7		14.5	11.1	39.5	22.2
29	1926-1927	0	78.1	72.9	76.9	75.3	77.9		85.7	86.2	87.3	82.8
24	1926-1927	3	41.4	36.5	36.9	31.7	58.6		64.6	65.2	86.2	86.2
29	1925-1926	15	18.2	19.9	23.6	29.5	39.2		47.8	51.5	82.2	82.8
22	1924-1925	27	12.1	18.7	19.6	24.4	39.5		45.1	49.5	81.5	95.5
No. of test items			70	50	26	25	72		15	33	6	1

4-5-6 in 1926-1927 as a base, and subtracting from these the successive percentages in the vertical column for each botanical category, we have⁵:

YEAR ELEMENTARY BOTANY TAKEN	Mos. AFTER COM- PLETING COURSE	COMP. MORPH.	HIST.	ALG.	CYT.	MORPH. FL. PL.	MYC.	PHYS.
1926-1927	3	36.7	36.4	40	43.6	19.3	21.1	21.0
1925-1926	15	59.9	53.0	53.3	45.8	38.7	37.9	34.7
1924-1925	27	66.0	54.2	57.3	50.9	38.4	40.6	36.7

The order of the botanical categories on the basis of the loss in retention is: 1, comparative morphology; 2, algology; 3, histology; 4, cytology; 5, mycology; 6, morphology of flowering plants; 7, physiology (5 and 6 are reversed in the 1925-1926 group). These data seem to corroborate the findings reported in Chapter II, viz., comparative morphology and algology do not enter into the content of the sequent courses. Morphology of flowering plants and physiology enter into the content of the sequent courses to the greatest extent and in these we find the least loss after intervals of fifteen and twenty-seven months.

THE RELATION OF BOTANICAL INFORMATION POSSESSED BY THE STUDENT TO ACHIEVEMENT IN SEQUENT COURSES

The determination of the relationship between the amount and kind of botanical information possessed by the student and his achievement in sequent courses is as intricate as it is important. The data afforded from the results of the testing program provide a possible attack upon this problem. The coefficient of correlation was computed between the scores attained on the botany test and the final grades in certain sequent courses. The coefficients of correlation were also computed between honor point ratios of the respective students and final grades in these sequent courses and between scores on the botany test and honor point ratios. With these coefficients of the zero order calculated, an attempt was made to determine the "net" correlation between scores on the botany

⁵ The categories, bacteriology and genetics, were not considered, since they contain too few items and these to a considerable extent known previous to entrance to the course, as would be indicated by the percentage of correct responses to them by entering freshmen.

test and grades in the sequent courses by "partialing out" or holding constant honor point ratios. The formula is:

$$r_{12.3} = \frac{r_{12} - r_{13} \cdot r_{23}}{\sqrt{(1 - r_{13}^2)(1 - r_{23}^2)}}.$$

The courses chosen to which this technique was applied were of three types: (1) those largely botanical in nature (as revealed by the analysis reported in Chapter II), viz., Plant Pathology and Silvics; (2) one quite specific in its botanical nature, viz., Wood Structure and Identification; and (3) one with practically no botanical content, viz., Forest Mensuration.

Table XXXI gives the correlations and the partial correlations computed between the three measures in the four sequent courses mentioned. These data are presented as illustrative of a technique that might afford some approach to the solution of the problem. Such limitations as the following are apparent:

1. The number of cases involved.
2. Unreliability of instructor's grades.
3. Limited possibilities of the botany test in measuring the botanical information of the student upon entrance to the sequent course.
4. The validity of the partial correlation as an instrument in the study of causation.
5. The validity of the operation of ruling out uncontrolled factors by partialing out the honor point ratio (intelligence test scores might have been preferable but they were not available for a sufficient number of the students involved).

TABLE XXXI
COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN THREE
MEASURES IN FOUR SEQUENT COURSES

COURSES	ρ_{12}	ρ_{13}	ρ_{23}	$\rho_{12.3}$	N
Plant Pathology	.76 $\pm$.08	.82 $\pm$.06	.61 $\pm$.12	.58 $\pm$.13	13
Silvics	.74 $\pm$.07	.60 $\pm$.10	.59 $\pm$.10	.61 $\pm$.10	20
Wood Structure and Identification	.56 $\pm$.11	.68 $\pm$.08	.66 $\pm$.09	.20 $\pm$.15	20
Forest Mensuration	.48 $\pm$.08	.60 $\pm$.06	.47 $\pm$.09	.28 $\pm$.10	36

The variables in this table are numbered as follows:

1. Final grade.
2. Score on botany test.
3. Honor point ratio.

Although these limitations render untenable any definite conclusions, certain implications may be warranted. From the values in the column heading, $\rho_{12.3}$, which may be read, "The correlation between the final grade and the score on the botany test with honor-point ratio held constant," it is observed that the correlations for Plant Pathology and Silvics, viz., $.58 \pm .13$ and $.61 \pm .10$, are considerably higher than that for Forest Mensuration, viz., $.28 \pm .10$. (The high probable error renders this coefficient quite untrustworthy.) Theoretically the last coefficient would presumably approach zero, since it does not appear that the final grade in Forest Mensuration would be dependent to any extent upon the grade attained in the botany test. This probably shows that all the uncontrolled factors have not been ruled out. The coefficients, $.58 \pm .13$ and $.61 \pm .10$, would seem to imply that botanical information as measured by the botany test might bear some relationship to achievement in such courses as Plant Pathology and Silvics, which are largely botanical in character. The high probable error in the coefficient of correlation for Wood Structure and Identification renders the coefficient untrustworthy. The explanation for not attaining as high a correlation as for Plant Pathology and Silvics, however, might be in the fact that Wood Structure and Identification is really a specialized course in histology. As such, the foundation for the pursuit of the course is laid during the progression of the course itself. That is, no recognition is made of the previous preparation of the student.

Summary.—The main problem of the investigations reported in this chapter centered around the determination of the permanence of learning in elementary botany. By permanence of learning, as used here, was meant the amount of information retained after certain intervals of time. The complete solution of this problem would involve a measurement of the time required for relearning. No attempt has been made in this study to measure relearning. The procedures by which certain measurements have been made have been described in the foregoing pages. This summary includes a brief statement of the more important data deduced, subject to the limitations imposed by the conditions of the investigation and the technique employed.

1. The instrument used for measuring retention was a botany test developed from previous final objective examinations given in General Botany 4-5-6. The validity of this test, based upon instructors' grades in General Botany 4-5-6 as a criterion, was found to be $.87 \pm .02$. The reliability as deter-

- mined by the "split" test method and estimated by the Spearman-Brown formula was $.93 \pm .01$.
2. The median score on the botany test of 126 students in the College of Agriculture and Forestry upon entering the course in General Botany 4-5-6 was 5.5.
 3. The median score on the botany test of twenty-four students in the College of Agriculture and Forestry as determined by the results from the components of the test given at the time of completing each quarter's work in General Botany 4-5-6 was 205; three months after completing the course, the median score for this group was 110.5.
 4. The median score on the botany test for a group of twenty-nine students in the College of Agriculture and Forestry fifteen months after completing General Botany 4-5-6 was 53; for the group of twenty-two students, twenty-seven months after completion of General Botany 4-5-6, the median score was 49.
 5. The mean score on the immediate recall test in General Botany 4-5-6 for a group of twenty-four students was 207.4; the mean score on the delayed recall test (given three months after completing the course) was 117.3. The loss in retention was 43.4 per cent.
 6. The mean score on the immediate recall test in General Botany 4-5 for a group of thirty-six students was 141.8; the mean score on the delayed recall test given six months after completing General Botany 4-5 was 74.1. The loss in retention was 47.8 per cent.
 7. The students who have the most botanical information (as measured by the botany test) at the time of completing General Botany 4-5 or General Botany 4-5-6 are likely to retain not only absolutely more but relatively more of this information after the lapse of six or three months in time.
 8. There is a qualitative difference in the nature of the botanical information retained. The order of loss in certain botanical categories from the greatest to the least is: 1, comparative morphology; 2, algology; 3, histology; 4, cytology; 5, mycology; 6, morphology of flowering plants; 7, physiology. The loss is greatest in those botanical categories which do not enter into the content of the sequent courses.
 9. There appears to be some relation between the botanical information possessed by the student and his achievement in those sequent courses which are largely botanical in nature.

Significance of the Findings.—Whether the losses in retention as reported in this study are high or low cannot be said. There are no bases upon which comparisons might be made, at least so far as the investigator is aware. The important thing bearing upon the problem under investigation in this study would seem to be how much of what is retained has functional value as the student pursues the sequent courses for which botany is presumed to be a prerequisite. Some evidence has

been given that certain of the constituents of the course in elementary botany (comparative morphology and algology) are largely lost during or after completing the sequent courses and that certain other constituents (morphology of flowering plants and physiology) are retained, relatively, to a greater extent. If this can be partly attributed to the functioning of certain elements and the non-functioning of others, the implication would seem to be the supplanting of the non-essential elements in the elementary botany course by those found through experimentation to be more essential.

If the loss in retention from the time of completing elementary botany to the time of entrance to the sequent course may be considered large, a possible stimulus to retention might be in requiring the student to pass the examination in elementary botany not only at the time of completing the course but also at the time of entrance to the sequent course for which it is a prerequisite. The justification of this procedure would seem to rest largely upon the incorporation into the elementary course of those botanical constituents that might be experimentally established as necessary for the successful pursual of the sequent course.

CHAPTER V

THE EFFECT OF CERTAIN FACTORS UPON ACHIEVEMENT

Problem.—The study reported in this chapter was directed at the determination of the possible effects of certain factors upon the achievement of students in General Botany. The factors considered were: (1) General Botany taken as a requirement or as an election; (2) previous preparation in high school science; (3) interest; (4) sex; and (5) intelligence.

Sources and Method.—The students for whom the data are recorded in this study took General Botany during the fall and winter quarters, 1927-1928. The students enrolled in the College of Science, Literature, and the Arts (including those taking the pre-business course and those in the School of Nursing) pursued the course designated as General Botany 1-2. The students enrolled in the College of Agriculture and Forestry took General Botany 4-5-6. The data for the latter students were available for the fall and winter quarters, 1927-1928, during which time the content of the course is designated as Botany 4-5. The contents of General Botany 1-2 and General Botany 4-5-6 are identical (see Table 5), the distinction between the two courses being in the time required for their respective completion. General Botany 1-2 is completed at the end of the winter quarter, General Botany 4-5-6 at the end of the spring quarter. The data given, therefore, for the students in the College of Agriculture and Forestry, when designated as General Botany 4-5, are comparable with those (under the same heading) for the students in the other colleges mentioned, to the extent that the same materials of instruction are covered. The factor of recency should be considered in making any comparisons between data for students in the College of Agriculture and Forestry and those for students in the College of Science, Literature, and the Arts. Obviously, those students taking General Botany 1-2, since the course was completed at the end of the winter quarter, necessarily have had the material represented in the content of General Botany 4-5 at an earlier date than those taking General Botany 4-5-6. Other factors—such as the nature of other

courses¹ pursued, an additional quiz-section period given to students in General Botany 1-2, and perhaps variation in materials emphasized—render any direct comparisons invalid to the extent that these factors may affect achievement. The comparisons, therefore, in the following discussion have been made between different groups within the College of Science, Literature, and the Arts or between different groups within the College of Agriculture and Forestry. In most cases the data for the students in the College of Science, Literature, and the Arts have been computed from the results of the test scores on both General Botany 4-5 and General Botany 4-5-6. This renders possible a comparison with the data for the students in the College of Agriculture and Forestry but subject to the restrictions mentioned above.

The instrument used, in all cases, for measuring the achievement of the students concerned was the botany test described in Chapter IV. The components of this test, designated as General Botany Test 4, 5, and 6, cover the content of General Botany 4, 5, and 6, respectively. This test was given to 288 students who entered the course in General Botany in the fall of 1927. The data showing the distribution of scores for this group have been previously presented in Table XIII. The same test was given at the end of the winter quarter, 1928, to as many of the group of 288 students as were then enrolled in the course and present for the examination. A measure of the gain in botanical information as determined by this test was therefore possible. The data from the test results were used for comparative purposes only for those students for whom there were available scores on the initial test and ratings from intelligence tests. This procedure reduced the number of usable test results, but the reduction in number was compensated for by having more measures for comparison.

The Findings.—The data considered in determining the possible effect of certain factors upon achievement are incorporated with the discussion that follows.

REQUIREMENT VERSUS ELECTION AS A FACTOR IN ACHIEVEMENT

The first factor studied was that in which an attempt was made to determine whether the achievement of students who were required to take General Botany differed significantly from that of students who

¹ Students in the College of Agriculture and Forestry take concurrently with General Botany 4-5-6 certain courses that have considerable botanical content, i.e., Farm Crops, Fruit Growing, and Dendrology.

elected the course. For the students in the College of Agriculture and Forestry, General Botany 4-5 is a required course. General Botany 1-2 is required for students in the School of Nursing. To the extent that General Botany 1-2 is one of a group of subjects, the selection of one of which is required, it may be considered as an elective subject for those students in the College of Science, Literature, and the Arts including those students who are taking the pre-business course. The data giving the percentile ranks in intelligence, the scores on the initial test, the scores on the final test, and the gains for that part of the content of General Botany 1-2 covered by the General Botany Test 4-5 for students in the College of Science, Literature, and the Arts are presented in Table XXXII and for those in the School of Nursing and the pre-business course in Table XXXIII. The mean gain for the students in the College of Science, Literature, and the Arts is 75; for the students in the pre-business course, 79.3; and for those in the School of Nursing, 75.6. The differences between these respective mean gains

are not significant ($\frac{D}{\sigma_{(diff)}}$ for the difference between 79.3 and 75 is .52). The mean gain of the students in the pre-business course is the highest. This group of students has the highest median rank in intelligence, i.e., 51, as compared with 49.5 for the students in the College of Science, Literature, and the Arts and 46.5 for the students in the School of Nursing. The quartile deviation, or Q, for the group of students in the College of Science, Literature, and the Arts is 20.2; for the group in the pre-business course, 16.5; and for the group in the School of Nursing, 26.0. Although the students in the School of Nursing are somewhat lower in intelligence ranking, their mean gain on the botany test is practically identical with that of the students in the College of Science, Literature, and the Arts and not significantly different from that of the students in the pre-business course. As far as revealed by this test, therefore, it would appear that there is no significant difference between the achievement of these particular students who are required to take General Botany 1-2 and that of those students who elect it. This is assuming, of course, that all other factors except that of requirement as compared with election are constant. Data are not available for determining the validity of this assumption.

As to what motive leads students to elect botany in lieu of physics or chemistry or some other subject in the group from which one election is required cannot be definitely stated. Interest may play a part, since

TABLE XXXII

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE COLLEGE OF
SCIENCE, LITERATURE, AND THE ARTS, 1927-1928

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5		
		Initial Score	Final Score	Gain
1	76	2	136	134
2	51	9	132	123
3	11	8	131	123
4	53	8	128	120
5	91	4	119	115
6	85	8	117	109
7	50	0	109	109
8	67	7	113	106
9	86	0	105	105
10	22	0	104	104
11	95	3	106	103
12	62	4	105	101
13	86	38	138	100
14	63	1	100	99
15	96	2	100	98
16	37	0	98	98
17	32	3	98	95
18	85	0	93	93
19	19	1	93	92
20	47	0	85	85
21	66	5	88	83
22	84	4	85	81
23	96	12	90	78
24	38	1	79	78
25	70	1	75	74
26	41	1	71	70
27	27	6	76	70
28	88	14	79	65
29	40	0	63	63
30	39	8	71	63
31	83	0	62	62
32	16	2	63	61
33	10	5	63	58
34	38	8	65	57
35	40	2	58	56
36	49	2	57	55

TABLE XXXII—*Continued*

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE COLLEGE OF
SCIENCE, LITERATURE, AND THE ARTS, 1927-1928

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5		
		Initial Score	Final Score	Gain
37	31	1	55	54
38	61	2	54	52
39	41	23	74	51
40	15	0	51	51
41	68	6	56	50
42	11	0	49	49
43	62	1	48	47
44	30	0	46	46
45	25	0	45	45
46	16	4	48	44
47	63	4	47	43
48	51	0	42	42
49	8	0	42	42
50	15	0	41	41
51	4	0	40	40
52	57	37	53	16
M	49.9	4.7	79.7	75
SD				±27.7
Q ₃	69.0			99.5
Md.	49.5			70
Q ₁	28.5			51

the index² of interest (as shown in Table XLIV) for students in the College of Science, Literature, and the Arts is 4.2 for the biological sciences as compared with .8 for the physical sciences; for students in the pre-business course—5 for the biological sciences as compared with .7 for the physical sciences. With respect to the choice between botany and zoology, Table XLIII reveals that the index of interest for botany is 9 as compared with 2 for zoology for the students in the College of Science,

² Determined by the ratio of likes to dislikes for high school subjects. There are undoubtedly many limitations that might be placed upon this criterion of interest but this one is mentioned as a possible explanation of the election of a subject.

TABLE XXXIII

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE SCHOOL OF NURSING
AND THE SCHOOL OF BUSINESS ADMINISTRATION, 1927-1928

SCHOOL OF NURSING					SCHOOL OF BUSINESS ADMINISTRATION				
Stu- dent's No.	Per- centile Rank in Intelli- gence	Botany 4-5			Stu- dent's No.	Per- centile Rank in Intelli- gence	Botany 4-5		
		Initial score	Final score	Gain			Initial score	Final score	Gain
1	93	31	184	153	1	90	0	148	148
2	18	0	104	104	2	49	4	134	130
3	48	0	103	103	3	41	2	117	115
4	30	0	102	102	4	79	0	106	106
5	71	0	100	100	5	55	0	102	102
6	12	0	96	96	6	71	3	104	101
7	97	0	89	89	7	43	0	93	93
8	19	4	83	79	8	80	0	86	86
9	55	5	80	75	9	72	1	82	81
10	45	3	77	74	10	28	0	80	80
11	21	7	79	72	11	1	10	80	70
12	83	10	80	70	12	43	1	70	69
13	57	6	76	70	13	78	2	69	67
14	39	1	68	67	14	74	3	69	66
15	96	11	77	66	15	36	9	72	63
16	39	5	63	58	16	44	2	58	56
17	52	0	56	56	17	89	17	71	54
18	17	0	54	54	18	31	2	55	53
19	12	1	53	52	19	64	11	61	50
20	9	0	52	52	20	11	1	48	47
21	70	4	42	38	21	51	3	31	28
22	99	5	39	34					
M	49.2	4.3	79.9	75.6		53.8	3.5	82.8	79.3
SD				±26.2					±29.03
Q ₃	71			96		74			101
Md.	46.5			71.0		51.0			70.0
Q ₁	19			56		41			56

Literature, and the Arts. Another possible explanation might lie in the estimation of the student with respect to the relative difficulty of courses as determined by the distribution of marks in the various courses from

which an election may be made. Of course, the student is not aware of the exact distribution but rumors become prevalent regarding the relative difficulty of courses. The following data indicate that there is some variation in the distribution of marks:

THE PERCENTAGE DISTRIBUTION OF MARKS IN COURSES UNDER 50 DURING THE INTERVAL 1921-1924³

COURSE	N	DF	DN	I	F	E	D	C	B	A
Botany	233	1.4	12.0	2.1	4.9	4.6	14.3	37.2	17.9	5.8
Animal biology	718	6.9	6.5	1.9	7.0	5.4	21.3	34.1	14.5	2.5
Chemistry	578	4.8	9.8	3.0	10.2	5.1	17.4	27.2	16.9	5.8
Physics	869	3.8	4.9	.9	12.7	5.3	17.6	26.7	22.1	6.1
Mathematics	526	9.7	7.3	1.1	13.7	2.6	18.6	28.9	13.8	4.5
Psychology	1020	2.7	3.3	1.8	7.8	1.7	19.0	43.1	15.4	5.5
English	2535	2.4	5.8	3.1	7.3	5.9	21.3	35.5	15.9	2.7

If totals from these data are computed for the courses concerned in this discussion to the right and left of the dividing line between D and C, there results:

	D AND BELOW	C AND ABOVE
Botany	39.3	60.9
Animal biology	49.0	51.1
Chemistry	50.3	49.9
Physics	45.2	54.9
Mathematics	53.0	47.2

From a consideration of these data, which show the least percentage of marks under the column heading "D and Below" and the highest percentage of marks under the column heading "C and Above," it may well be that some students elect botany in preference to other courses in a given group on the basis of relative difficulty, as indicated by the distribution of marks.

Tables XXXIV (a) and XXXIV (b) give the percentile ranks in intelligence, initial scores, final scores, and gains on the General Botany 4-5 Test of students in the College of Agriculture and Forestry. The mean gain for the group of students enrolled in the College of Agriculture was 90.6 and for those in the College of Forestry, 82.3. Although

³ John E. Bohan. Students' Marks in University Courses. (Doctor's thesis, University of Minnesota, 1926), pp. 70-75. To be published by the University of Minnesota Press, 1930.

the difference between these mean gains is not statistically significant ($\frac{D}{\sigma_{(diff)}} = .59$), some explanation will be suggested for the difference which does exist. The median score in percentile ranking in intelligence for the students in the College of Agriculture is 41 and for the students in the College of Forestry, 56. The quartile deviations for the two groups are 24.0 for the students in the College of Agriculture and 25.5 for the students in the College of Forestry. Apparently the students in forestry were slightly superior to those of the corresponding groups in agriculture in intelligence-rating and still attained a lower mean score. A partial explanation may lie in the nature of other courses pursued. Perhaps an additional explanation may be afforded from an analysis of the data given in Table XXXV, which gives the distribution of honor point ratios by classes in the College of Agriculture and Forestry. From these data it is observed that the percentage of students in the freshman year in the College of Agriculture with honor point ratios below 1 is forty-one as compared with seventy-three for the freshmen in the College of Forestry. This difference might be caused to some extent by the variation in the marking systems of the instructors in the respective colleges. The distribution of marks for certain freshman or sophomore courses in the College of Agriculture and the distribution in the College of Forestry are given by Bohan:⁴

	N	I	F	E	D	C	B	A
Agricultural biochemistry	128	3.1	4.7	9.4	23.4	32.0	20.3	7.0
Animal husbandry	137	....	4.4	7.3	24.8	37.2	20.4	5.8
Horticulture	52	7.7	1.9	....	5.8	23.1	46.2	15.4
Plant pathology .....	.....	19.2	....	3.8	7.7	11.5	42.3	15.4
Forestry	178	8.4	6.7	3.4	7.3	25.8	35.4	12.9

Whereas there is some variation, the tendency for greater leniency in marking would be in the direction of the courses in forestry. The average of the percentages of grades with values of D and below for the four courses cited in agriculture is 30.8 as compared with 25.8, the total percentage of grades with values of D and below for the courses in forestry.

The unequal distribution of honor point ratios, as noted above, apparently registers some variation in a trait such as industry or application among the freshman students in the College of Agriculture and Forestry.

⁴ Bohan. *Op. cit.*, pp. 80-82.

TABLE XXXIV(a)

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE
COLLEGE OF AGRICULTURE, 1927-1928

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5		
		Initial Score	Final Score	Gain
1	61	6	151	145
2	97	25	160	135
3	53	1	136	135
4	52	10	134	124
5	91	0	118	118
6	95	22	134	112
7	67	4	114	110
8	57	6	116	110
9	65	5	112	107
10	16	3	109	106
11	32	14	119	105
12	90	4	107	103
13	59	3	101	98
14	17	13	110	97
15	50	0	95	95
16	21	6	101	95
17	16	9	103	94
18	36	12	103	91
19	23	4	90	86
20	86	0	82	82
21	12	0	82	82
22	41	5	80	75
23	76	11	84	73
24	19	9	82	73
25	9	0	70	70
26	98	3	72	69
27	6	6	73	67
28	8	2	68	66
29	32	0	65	65
30	64	2	64	62
31	8	7	66	59
32	34	4	46	42
33	1	0	39	39
M	45.2	5.9	96.5	90.6
SD				± 25.6
Q ₃	65.0			107.0
Md.	41			94
Q ₁	17.0			70.0

TABLE XXXIV (b)

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE
COLLEGE OF FORESTRY, 1927-1928

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5		
		Initial Score	Final Score	Gain
1	67	0	131	131
2	72	0	128	128
3	26	6	130	124
4	21	2	126	124
5	79	1	111	110
6	97	6	115	109
7	72	0	105	105
8	56	2	105	103
9	92	20	123	103
10	12	2	104	102
11	81	0	101	101
12	63	2	98	96
13	46	8	101	93
14	69	4	95	91
15	64	2	93	91
16	65	2	93	91
17	76	8	94	86
18	48	3	80	77
19	1	0	76	76
20	20	2	73	71
21	53	0	70	70
22	8	2	70	68
23	54	0	65	65
24	76	10	73	63
25	16	0	62	62
26	46	3	63	60
27	2	2	61	59
28	89	14	69	55
29	19	20	75	55
30	64	14	59	45
31	15	2	46	44
32	40	3	36	33
33	81	6	32	26
M	51.2	4.4	86.7	82.3
SD				± 27.4
Q ₃	72			103.0
Md.	56			86
Q ₁	21.0			62.0

TABLE XXXV

HONOR POINT RATIOS BY CLASSES IN THE COLLEGE OF AGRICULTURE AND FORESTRY

COLLEGE	CLASS	N	PERCENTAGE OF STUDENTS WITH HONOR POINT RATIOS BETWEEN					
			-00	.00-.49	.50-.99	1.00-1.49	1.50-1.99	2 or Above
Agriculture	Freshman	38	5	10	26	24	24	11
Forestry	Freshman	52	12	24	37	12	12	3
Agriculture	Sophomore	56	....	14	29	34	16	7
Forestry	Sophomore	51	....	17	53	10	14	6
Agriculture	Junior	31	....	....	19	39	26	16
Forestry	Junior	29	....	....	17	45	17	21
Agriculture	Senior	21	....	....	28	49	14	9
Forestry	Senior	20	....	....	25	45	20	10
Total		298						

The coefficients of correlation between scores on the botany test and percentile ranks in intelligence were $.49 \pm .09$ for the students in agriculture and $.28 \pm .11$ for the students in forestry (see Table XLVI). While the latter coefficient is rather untrustworthy on account of the high probable error, these coefficients of correlation would appear to indicate that these students in agriculture had lived up to their potentialities as students to a greater extent than had those in forestry (that is, as far as is indicated by the difference between the mean gains of the two groups as measured by the botany test).

Further study of the data in Table XXXV shows that the differences between the percentages of honor point ratios become less and less for the students in the two colleges until by the senior year the distributions are quite identical. As a matter of fact, the students in forestry show a slight superiority by this time.

When compared with the mean gains on the botany test of the students in the College of Science, Literature, and the Arts, the School of Nursing, and those in the pre-business course, it is observed that the mean gains of the students in the College of Agriculture and Forestry are higher. Such limiting factors as those previously mentioned, however, vitiate any direct comparisons.

RELATION OF PREVIOUS PREPARATION IN SCIENCE TO ACHIEVEMENT

Whereas the results of the initial test revealed a slight superiority for those students who had taken biological science in high school, the

question as to the effect of previous preparation in science might be more fully answered if the effect upon the ultimate achievement were measured. Table XXXVI gives the distribution of high school sciences taken by 288 students who began the study of General Botany in the fall quarter, 1927. These data were obtained from statements elicited from the students at the time of taking the botany test and subsequently verified by tracing down their entrance credits as given in the records of the registrar. From these data it is observed that 149, 146, and 141 of the group of 288 students had had chemistry, physics, and general science, respectively. Biology, botany, and zoology had been taken by 95, 67, and 28 of the students, respectively. A considerable number had had preparation in more than one science.

TABLE XXXVI

HIGH SCHOOL SCIENCES TAKEN BY STUDENTS WHO WERE ENROLLED IN GENERAL BOTANY, FALL QUARTER, 1927

COLLEGE OR SCHOOL	N	GEN. SCI.	BIOL- OGY	BOT- ANY	ZOOLOG- OGY	PHYS- ICS	PHYSI-		PHYSI- OLOGY	AGRI- CUL- TURE
							CHEM- ISTRY	OGRAPHY		
Agriculture	62	30	28	12	2	46	38	3	3	2
Forestry	64	38	24	9	3	43	39	9	7	2
S.L.A.	99	40	28	31	14	36	44	6	8	2
Business	33	19	8	8	5	9	8	3	2	1
Nursing	30	14	7	7	4	12	20	3	6	1
Total	288	141	95	67	28	146	149	24	26	8

In the College of Agriculture and Forestry it was possible to compare two groups on the basis of previous preparation in science. One group had had only the physical sciences; the other, both physical and biological sciences. There were too few students who had had only the biological sciences to form a group for comparison. The data for the group with previous preparation in biological and physical sciences are given in Table XXXVII; for the group with previous preparation in physical science in Table XXXVIII. The mean gain for the group with biological and physical sciences was 83.1; for the group with physical science, 82.7. The median rankings in intelligence for these groups were 53.5 and 48, respectively. Other things being equal, it would appear that the additional factor of biological preparation for

the members of one group had not affected their achievement in General Botany 4-5 as measured by the botany test when compared with the achievement of the group with training only in the physical sciences.

TABLE XXXVII

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, AND FINAL SCORES AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE COLLEGE OF
AGRICULTURE AND FORESTRY WHO TOOK BIOLOGICAL
AND PHYSICAL SCIENCES IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	INITIAL SCORE	BOTANY 4-5	
			Final Score	Gain
1	53	5	136	131
2	21	2	126	124
3	32	17	134	117
4	67	4	114	110
5	95	25	134	109
6	90	4	107	103
7	12	2	104	102
8	65	11	112	101
9	32	21	119	98
10	81	7	101	94
11	69	4	95	91
12	64	2	93	91
13	16	14	103	89
14	41	6	80	74
15	76	11	84	73
16	8	2	68	66
17	54	0	65	65
18	19	18	82	64
19	76	16	73	57
20	2	4	61	57
21	64	18	59	41
22	1	0	39	39
23	34	9	46	37
24	98	11	72	61
M	48.8	8.9	92	83.1
SD				± 26.6
Q ₃	72.5			102.5
Md.	53.5			90.0
Q ₁	20.0			62.5

TABLE XXXVIII

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, AND FINAL SCORES AND GAINS
ON GENERAL BOTANY 4-5 TEST OF STUDENTS IN THE COLLEGE OF
AGRICULTURE AND FORESTRY WHO TOOK PHYSICAL
SCIENCE IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	INITIAL SCORE	BOTANY 4-5	
			Final Score	Gain
1	97	33	160	127
2	26	6	130	124
3	72	6	128	122
4	91	0	118	118
5	79	1	111	110
6	57	6	116	110
7	97	8	115	107
8	72	0	105	105
9	56	2	105	103
10	59	3	101	98
11	50	0	95	95
12	46	10	101	91
13	63	6	95	89
14	21	12	101	89
15	61	16	103	87
16	85	9	94	85
17	36	19	103	84
18	12	0	82	82
19	48	3	80	77
20	1	0	76	76
21	53	0	70	70
22	9	0	70	70
23	32	0	65	65
24	16	0	62	62
25	46	3	63	60
26	64	7	64	57
27	8	11	66	55
28	89	22	69	47
29	2	1	48	47
30	15	2	46	44
31	40	3	36	33
32	15	0	33	33
33	16	3	109	106
M	46.5	5.8	88.5	82.7
SD	± 28.8			± 26.1
Q_3	64.0			105
Md.	48.0			85
Q_1	16.0			62

In the College of Science, Literature, and the Arts it was possible to compare three groups on the basis of previous preparation in science. The first group had had previous preparation in physical science; the second, in biological science; and the third, in both biological and physical sciences. In addition, a fourth group⁵ that had had botany as a biological science was considered. The data from these respective groups are given in Tables XXXIX, XL, XLI, and XLII. From these tables the following comparisons are made:

	PHYSICAL SCIENCE	BIOLOGICAL SCIENCE	PHYSICAL AND BIOLOGICAL SCIENCES	BOTANY
Number of cases.....	27	17	34	26
Mean gain	134.9	110.1	116.1	103.1
Median percentile rank in				
intelligence	63	63	50	51.5
Q in intelligence	24	24	24.5	21
				D
				$\sigma_{(diff)}$
Between mean gains of physical science and botany groups.....				2.9
Between mean gains of physical science and biological science groups				2.15
Between mean gains of physical science and physical and biological science groups				1.8

From these comparisons it is observed that the difference between the mean gain of the group with previous preparation in physical science and that of the group with previous preparation in botany is practically a significant difference (2.9 as compared with a criterion of 3). The difference between the mean gain of the group with previous preparation in physical science and that of the group with previous preparation in biological science also approaches a significant difference. The explanation of these differences can only be inferred. From a comparison of the median ranks in intelligence and the quartile deviations, the groups with previous preparation in physical science and previous preparation in biological science would appear identical. It may be that the students without previous experience in botany or biological science apply their efforts more uniformly to the acquisition of botanical knowledge, since they apparently would be dealing continu-

⁵ This group would include all of those students who had had biological science and in addition some students who also had had physical science.

TABLE XXXIX

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5-6 TEST OF STUDENTS IN THE COLLEGE OF SCIENCE,
LITERATURE, AND THE ARTS WHO TOOK PHYSICAL SCIENCE IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	76	5	202	197	131
2	49	8	201	193	126
3	53	18	199	181	110
4	86	0	170	170	105
5	79	0	168	168	106
6	55	0	168	168	102
7	32	0	167	167	92
8	71	0	157	157	100
9	30	15	166	151	87
10	97	0	148	148	89
11	95	6	151	145	100
12	33	0	145	145	80
13	84	4	148	144	81
14	63	7	148	141	93
15	66	7	138	131	81
16	88	1	124	123	77
17	11	0	120	120	63
18	39	4	120	116	67
19	70	1	115	114	74
20	15	2	112	110	61
21	83	0	108	108	62
22	40	0	103	103	63
23	72	7	107	100	75
24	52	0	91	91	56
25	35	8	99	91	51
26	99	11	94	83	28
27	17	0	79	79	54
M	58.9	3.9	138.8	134.9	82
SD				±37.04	
Q ₃	83.0			167.0	
Md.	63.0			141.0	
Q ₁	35.0			108.0	

TABLE XL

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS ON GENERAL BOTANY 4-5-6 TEST OF STUDENTS IN THE COLLEGE OF SCIENCE, LITERATURE, AND THE ARTS WHO TOOK BIOLOGICAL SCIENCE IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	93	41	259	218	143
2	65	4	166	162	101
3	37	0	148	148	98
4	85	7	147	140	86
5	19	1	140	139	92
6	96	12	129	117	65
7	74	3	120	117	66
8	88	16	130	114	63
9	96	12	129	117	65
10	64	12	111	99	49
11	51	0	93	93	42
12	41	31	117	86	43
13	60	2	83	81	55
14	8	0	64	64	42
15	63	4	64	60	43
16	31	8	87	79	47
17	15	5	42	37	36
M	58	9.3	119.4	110.1	66.8
SD				± 37.3	± 27.8
Q ₃	85			139.0	86.0
Md.	63			117.0	63.0
Q ₁	37			81.0	43.0

ously with new material. On the other hand, those students who have had some training in the biological sciences may be prone to neglect certain phases that they feel they already know.

From the data deduced from these comparisons it would appear that with respect to these particular students, as measured by the botany test, the achievement in botanical information of those students whose previous preparation has been in the physical sciences is equal, if not superior, to that of those students whose previous training has been in the biological sciences.

TABLE XLI

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5-6 TEST OF STUDENTS IN THE COLLEGE OF SCIENCE,
LITERATURE, AND THE ARTS WHO TOOK BIOLOGICAL AND
PHYSICAL SCIENCES IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	11	11	195	184	120
2	85	12	195	183	105
3	52	12	196	184	120
4	91	12	189	177	107
5	86	46	209	163	92
6	18	3	161	158	101
7	71	3	154	151	101
8	41	1	147	146	90
9	67	14	185	171	99
10	2	2	148	146	94
11	80	0	143	143	86
12	96	14	156	142	76
13	19	4	140	136	79
14	42	11	144	133	84
15	21	9	136	127	70
16	45	9	125	116	68
17	55	5	117	112	75
18	1	10	111	101	70
19	73	1	101	100	54
20	48	23	122	99	80
21	57	10	107	97	66
22	12	1	98	97	52
23	39	9	98	89	54
24	68	9	94	85	47
25	27	12	96	84	64
26	11	1	84	83	47
27	78	2	79	77	67
28	40	2	79	77	56
29	38	2	78	76	63
30	16	4	78	74	44
31	62	1	74	73	47
32	70	7	64	57	35
33	69	9	63	54	40
34	57	40	92	52	18
M		9.1	125.2	116.1	72.5
SD				±40.1	
Q ₃	70			146.0	
Md.	50			106.5	
Q ₁	21			83.0	

TABLE XLII

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5-6 TEST OF STUDENTS IN THE COLLEGE OF SCIENCE,
LITERATURE, AND THE ARTS WHO TOOK BOTANY IN HIGH SCHOOL

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	93	41	259	218	143
2	52	12	196	184	120
3	85	12	195	183	105
4	65	4	166	162	101
5	19	1	140	139	92
6	19	4	140	136	79
7	45	9	125	116	68
8	88	16	130	114	63
9	96	12	129	107	65
10	1	10	111	101	70
11	64	12	111	99	49
12	51	0	93	93	42
13	41	31	117	86	43
14	68	9	94	85	47
15	27	12	96	84	64
16	11	1	84	83	47
17	60	2	83	81	55
18	31	8	87	79	47
19	78	2	79	77	67
20	40	2	79	77	56
21	38	2	78	76	63
22	16	4	78	74	44
23	8	0	64	64	42
24	70	7	64	57	35
25	69	9	63	54	40
26	57	40	92	52	13
M	49.7	10.2	113.3	103.1	63.9
SD				± 42.4	
Q ₃	69.0			116	
Md.	51.5			85.5	
Q ₁	27.0			77	

THE EFFECT OF INTEREST UPON ACHIEVEMENT

Upon entrance to the University of Minnesota, students fill out a "personnel folder." Among the responses called for is one that asks the student to indicate from a list of high school subjects the two that he liked best and the two that he disliked the most. A second item asks the student to indicate the subjects in college in which he expects to be most interested. A third statement calls for an indication of the occupational choice of the student upon his entrance to the University. Whereas it is recognized that the responses to these items may be conditioned, it is believed that they be taken as quite frank expressions on the part of the student. At least the responses might be considered to be less conditioned at this time than as if they were called for in a particular course. For example, if they were called for in a course in botany, a student might be more likely to consider that the nature of his response would bear a certain relationship to his standing in that course. The data reported here were obtained from the responses of students in the College of Agriculture, Forestry, and Home Economics and from those of a limited number of the students concerned in this study from the College of Science, Literature, and the Arts to the items mentioned above. It is recognized that the technical nature of interests is baffling and no attempt has been made to measure them directly; but although the nature of interests may be only vaguely defined, there is manifestation enough of their powers for motivation perhaps to warrant an attempt at determining any of their effects, even if the validity of the procedure cannot be firmly established.

Table XLIII gives the likes and dislikes of high school subjects as expressed by 727 students at the time of entrance to the University of Minnesota. The distribution is given by colleges. The data for the students in the College of Science, Literature, and the Arts, the School of Nursing, and the School of Business Administration (pre-business course) are limited to those concerned in this study for whom data were available. Table XLIV gives the same data and, in addition, what has been termed an index of interest, which is the ratio of likes to dislikes for any given group of subjects. From a study of these indices it is observed that the students in the College of Agriculture and Forestry are quite predominantly interested in science as compared with the other groups of subjects. They also manifest a greater liking for the biological sciences as compared with the physical. In so far as the limited number permits a

TABLE XLIII

LIKES AND DISLIKES OF HIGH SCHOOL SUBJECTS AS EXPRESSED BY STUDENTS AT THE TIME OF ENTRANCE TO THE UNIVERSITY OF MINNESOTA

Likes in high school subjects	School or College	N	Bio. Sciences						Phys. Sci.		Mathematics			Soc. Sci.			English		Foreign Languages					Vocational														
									Physics	Chemistry	Total	Algebra	Geometry	General Mathematics	Total	History	Social Science	Geography	Literature	Composition	Total	French	German	Spanish	Scandinavian	Greek	Total	Commercial	Industrial Arts	Mechanical Drawing	Music	Painting or Drawing	Home Economics	Animal Husbandry	Total			
			General Science	Biology	Botany	Zoology	Physiology	Psychology																												Physiology	Psychology	History
For.	For.	162	20	26	14	3	2	1	66	40	32	72	19	28	12	59	36	12	0	48	25	9	34	4	2	0	4	0	0	7	3	14	6	4	0	0	34	
Ag.	Ag.	153	19	16	17	3	4	0	59	45	45	90	25	31	11	67	36	12	0	48	23	9	32	3	2	0	0	0	7	9	3	13	10	2	0	0	37	
H.E.	H.E.	284	24	29	16	3	16	0	88	12	51	63	38	35	15	88	49	25	0	74	93	33	126	25	34	10	4	4	0	77	13	32	0	18	20	7	1	91
S.L.A.	S.L.A.	81	7	9	9	2	1	0	28	9	7	16	8	3	5	16	16	7	3	26	33	10	43	1	11	0	2	0	0	14	6	0	0	8	2	2	0	18
Bus.	Bus.	30	4	3	2	0	0	0	9	1	1	2	1	1	1	3	9	5	0	14	12	3	15	4	4	0	1	0	0	9	3	0	1	3	1	0	0	8
Nurs.	Nurs.	17	1	2	1	0	0	0	4	4	6	10	6	1	0	7	2	0	0	2	5	1	6	1	2	0	0	0	3	1	0	0	3	0	0	0	4	
Dislikes in high school subjects	For.	.....	2	1	0	0	0	0	3	16	11	27	37	26	12	75	17	2	1	20	49	40	89	38	9	0	4	0	0	51	10	3	5	6	3	0	0	27
Ag.	Ag.	.....	2	0	3	1	4	0	10	12	11	23	38	22	9	69	22	3	0	25	42	43	85	33	5	1	3	0	1	43	6	0	4	6	3	0	0	19
H.E.	H.E.	.....	12	4	5	3	8	0	32	37	32	69	52	84	32	168	84	9	0	93	18	32	50	55	18	2	3	2	0	80	11	0	0	5	3	0	0	19
S.L.A.	S.L.A.	.....	2	3	1	1	0	0	7	13	6	19	21	28	7	56	19	1	0	20	14	8	22	18	7	0	0	0	25	2	0	0	2	0	0	2	0	6
Bus.	Bus.	.....	0	0	1	1	0	0	1	2	1	3	8	10	10	28	4	0	0	4	6	4	10	4	3	0	0	0	0	7	0	0	3	0	0	1	0	4
Nurs.	Nurs.	.....	2	0	0	0	0	0	2	1	1	2	1	2	1	4	5	0	0	5	4	3	7	5	1	1	0	0	0	7	0	0	0	1	1	0	0	2

TABLE XLIV

RATIOS OF LIKES TO DISLIKES OF HIGH SCHOOL SUBJECTS AS EXPRESSED BY STUDENTS AT THE TIME OF ENTRANCE TO THE UNIVERSITY OF MINNESOTA

SCHOOL OR COLLEGE	N	GENERAL SCIENCES				BIOLOGICAL SCIENCES				PHYSICAL SCIENCES				MATHEMATICS			
		Like		Dislike		Like		Dislike		Like		Dislike		Like		Dislike	
		Index*	Index	Index*	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index
Agriculture	153	19	2	9.5	40	8	5.0	23	3.9	67	69	.97					
Home Economics	284	24	12	2.0	64	20	3.2	63	.9	88	168	.5					
Forestry	162	20	2	10.0	46	1	46.0	72	27	59	75	.8					
S.L.A.	81	7	2	3.5	21	5	4.2	16	19	16	56	.3					
Business	30	4	0	....	5	1	5.0	2	.7	3	28	.1					
Nursing	17	1	2	.5	3	0	....	10	2	7	4	1.8					
Total	727	75	20	3.8	179	35	5.1	253	143	240	400	.6					

SCHOOL OR COLLEGE	N	SOCIAL SCIENCES				ENGLISH				MODERN AND CLASSICAL LANGUAGES				VOCATIONAL SUBJECTS			
		Like		Dislike		Like		Dislike		Like		Dislike		Like		Dislike	
		Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index
Agriculture	153	48	25	1.9	32	85	.4	7	43	.16	37	19	1.9				
Home Economics	284	74	93	.8	126	50	2.5	77	80	.96	91	19	4.7				
Forestry	162	48	20	2.4	34	89	.4	10	51	.2	34	27	1.3				
S.L.A.	81	26	20	1.3	43	22	1.9	14	25	.56	18	6	3.0				
Business	30	14	4	3.5	15	10	1.5	9	7	1.3	8	4	2.0				
Nursing	17	2	5	.4	8	7	1.1	2	8	.25	4	2	2.0				
Total	727	212	167	1.3	258	263	.98	119	214	.56	192	77	2.5				

* Ratio of likes to dislikes.

generalization, it may also be said that the other groups of students express a liking for science, more especially the biological sciences. The nurses indicate a greater liking for the physical sciences than do those students in the College of Science, Literature, and the Arts or the School of Business Administration. It is in particular reference to the liking evidenced for biological science that this study is concerned.

Tables 39 and 40 give the college subjects that students in the College of Agriculture and Forestry and those that students in the College of Science, Literature, and the Arts expect to be interested in, respectively. These choices appear to be largely a reflection of the likes expressed for high school subjects.

Table 41 gives the occupational choices of 232 students in the College of Agriculture and Forestry. Table 42 gives the same data for eighty-seven students in the College of Science, Literature, and the Arts. Whether these choices are realized cannot be said. The significant thing in so far as this investigation is concerned is that only two students of these groups expect to become botanists. Also, that for certain occupational choices, such as horticulturist, florist, plant pathologist, and agronomist, diversification in botanical training is called for.

From an analysis of the responses of the students concerned in this study in which they indicated the two high school subjects that they liked best, there was possible a division of the students into three groups. One group indicated studies, both of which were sciences, as the two high school subjects best liked; a second group—one science and one non-science; and the third group—two subjects that were not sciences. Accordingly, the achievements of these respective groups in General Botany were compared. Table 43 gives the percentile rank in intelligence, the initial score, the final score, and the gain on the General Botany Test 4-5 of those students in the College of Agriculture and Forestry who indicated that the two high school subjects best liked were sciences. Table 44 gives the same data for those students who selected a science and a non-science as their favorite high school subjects. Table 45 gives the same data for those students who selected subjects other than sciences as their favorite high school studies. The comparisons from the data in these tables will be found on page 128. Such disparity in ranking in intelligence and the limited number of cases would appear to vitiate any comparisons that might be made. One might question the advisability of the selecting of a career such as agriculture affords, by the group who evidenced no liking for science.

FAVORITE SUBJECTS

	SCIENCE	SCIENCE AND NON-SCIENCE	NON-SCIENCE
Number.....	17	20	15
Mean gain	89.7	79.5	74.5
Md. percentile rank in intelligence.....	52	56	22
Q in intelligence	30	17	27.5

The data for the group of students in the College of Science, Literature, and the Arts who indicated sciences as the two high school subjects that were liked best are given in Table 46; for the students who selected a science and a non-science, in Table 47; and for the group of students who selected subjects other than science, in Table 48. From the data in these tables the following comparisons are made:

FAVORITE SUBJECTS

	SCIENCE	SCIENCE AND NON-SCIENCE	NON-SCIENCE
Number	12	25	37
Mean gain	136.3	108.6	124.2
Md. percentile rank in intelligence.....	49.5	41	61
Q in intelligence.....	18	26	18

$\frac{D}{\sigma_{(diff)}}$ —between 136.3 and 124.2 is .9; between 136.3 and 108.6 is 1.98.

Although the differences obtained are not statistically significant and the number of cases is quite limited, there is some indication that those students who selected two sciences as their favorite high school subjects may reveal by this selection a certain type of scientific interest that manifests itself in their achievement in a course in science. The median rank in intelligence of this group was 11.5 below that of the non-science group while the mean gain was 12.1 points higher. The group with likes divided between science and non-science studies attained the lowest gain. This group also had the lowest median rank in intelligence.

RELATION OF SEX TO ACHIEVEMENT

The students in the College of Agriculture and Forestry who were concerned in this study were men. The students in the School of Nursing were women. The majority of the students in the School of Busi-

ness Administration were men. In an attempt to determine the influence of sex as a factor in achievement of General Botany there remained for comparison the achievements of the men and women in the College of Science, Literature, and the Arts. The percentile ranks in intelligence, initial scores, final scores, and gains of these two groups of students are given in Tables XLV (a) and XLV (b). The mean gain for a group of thirty-one men was 133.7; for a group of forty women, 118.7. The median ranking in intelligence and the quartile deviation for the men were 51 and 18. These respective measures for the group of women were 45 and 21. While the difference between the mean gains of these groups is not statistically significant ($\frac{D}{\sigma_{(diff)}} = 1.6$), there appears to be an indication of superior achievement on the part of men in general botany. This may be accounted for partly by the slight superiority revealed by the intelligence measures. It was observed that the mean gain of the group in the School of Business Administration (see Table XXXIII) was slightly superior to that of the School of Nursing. In addition to the factor of intelligence previously mentioned, there may be one of sex differences. This factor may be also involved in the superiority of the mean gains of the students in the College of Agriculture and Forestry over those of the other groups. That is, this may be an additional factor to those limiting factors previously mentioned.

RELATIONSHIP BETWEEN INTELLIGENCE AND ACHIEVEMENT

The coefficients of correlation between the scores on the botany test and percentile ranks in intelligence of the students concerned in this study are given in Table XLVI. For the groups in the School of Nursing and the School of Business Administration the probable errors are so high as to make the coefficients of correlation unreliable, i.e., $.14 \pm .14$ and $.25 \pm .14$, respectively. The coefficient of correlation for the students in the College of Agriculture is $.49 \pm .09$; for the students in the College of Forestry, $.28 \pm .11$; and for the students in the College of Science, Literature, and the Arts, $.44 \pm .08$. These coefficients of correlation, while low, would indicate that the students in the College of Agriculture and the College of Science, Literature, and the Arts are living up to their potentialities for achievement to a greater extent than those students in the other colleges.

Summary and Implications of the Findings.—The particular concern

TABLE XLV(a)
 PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
 ON GENERAL BOTANY 4-5-6 TEST OF MEN IN THE COLLEGE OF
 SCIENCE, LITERATURE, AND THE ARTS

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	49	4	201	197	130
2	85	8	195	187	109
3	51	9	196	187	123
4	11	8	195	187	123
5	67	7	185	178	106
6	41	2	171	169	115
7	55	0	168	168	102
8	96	2	164	162	98
9	47	0	151	151	85
10	95	3	151	148	103
11	41	1	147	146	70
12	43	0	144	144	93
13	71	3	145	142	101
14	66	5	138	133	83
15	38	1	124	123	78
16	74	3	120	117	63
17	70	1	118	117	74
18	27	6	122	116	70
19	40	2	117	115	56
20	16	2	112	110	61
21	83	0	108	108	62
22	31	1	101	100	54
23	64	11	111	100	50
24	44	2	95	93	56
25	15	0	91	91	51
26	68	6	94	88	50
27	4	0	78	78	40
28	78	2	79	77	67
29	38	8	78	70	57
30	80	0	143	143	86
31	76	2	202	200	134
M		3.2	136.9	133.7	82.3
SD				±37.6	
Q ₃	74			168	
Md.	51			133	
Q ₁	38			100	

TABLE XLV(b)

PERCENTILE RANKS IN INTELLIGENCE, INITIAL SCORES, FINAL SCORES, AND GAINS
ON GENERAL BOTANY 4-5-6 TEST OF WOMEN IN THE COLLEGE OF
SCIENCE, LITERATURE, AND THE ARTS

STUDENT'S No.	PERCENTILE RANK IN INTELLIGENCE	BOTANY 4-5-6			BOTANY 4-5 GAIN
		Initial Score	Final Score	Gain	
1	90	0	225	225	148
2	53	8	199	191	120
3	91	4	189	185	115
4	86	38	209	171	100
5	79	0	168	168	106
6	86	0	166	166	105
7	32	3	167	164	95
8	47	0	148	148	85
9	85	0	147	147	93
10	63	1	148	147	99
11	62	4	170	166	101
12	28	0	145	145	80
13	22	0	145	145	104
14	96	12	156	144	78
15	19	1	140	139	92
16	84	0	135	135	85
17	50	0	122	122	109
18	41	1	120	119	70
19	10	5	120	115	58
20	70	1	115	114	74
21	30	0	104	104	46
22	40	0	103	103	63
23	61	2	103	101	52
24	1	10	111	101	70
25	41	23	117	94	51
26	27	6	96	93	70
27	89	17	108	91	54
28	36	9	96	87	68
29	31	2	87	85	53
30	43	1	127	126	69
31	11	1	84	83	47
32	49	2	83	81	55
33	72	7	107	100	75
34	40	2	79	77	56
35	16	4	78	74	44
36	51	3	70	67	28
37	57	37	92	55	16
38	15	0	41	42	37
39	8	0	64	64	42
40	11	0	63	63	49
M		5.0	123.7	118.7	74.1
SD				± 41.3	
Q.	71			147.0	
Md.	45			114.5	
Q.	29			86.0	

TABLE XLVI

COEFFICIENTS OF CORRELATION (RANK-DIFFERENCE METHOD) BETWEEN SCORES ON
GENERAL BOTANY 4-5-6 TEST AND PERCENTILE RANKS IN INTELLIGENCE

	SCORES ON BOTANY TEST OF STUDENTS IN				
	College of Agriculture	College of Forestry	College of S.L.A.	School of Nursing	School of Bus. Adm.
Percentile ranks in intelligence	$\rho = .49 \pm .09$	$\rho = .28 \pm .11$	$\rho = .44 \pm .08$	$\rho = .14 \pm .14$	$\rho = .25 \pm .14$
N	33	33	52	22	21

of the investigation reported in this chapter was an attempt to determine the possible effect of certain factors upon the achievement of students in General Botany. Of the possible determinants of achievement, this study dealt with (1) botany taken as an elective and as a required course; (2) previous preparation in high school science; (3) interest as evidenced by likes of certain subjects; and (4) sex. The procedure employed in attempting to measure the influence of these factors has been described.

On the whole the findings were negative rather than positive. The differences found in practically all the comparisons made were not statistically significant. Either real differences did not exist or the limited number of cases and the large variability of the groups made impossible their detection by the means employed. Certain tendencies appeared which will be briefly considered:

1. Where comparisons were possible there was no significant difference between the achievement of those students who took botany as a required subject and that of those who took it as an elective. It is highly probable that some of the students who took botany as a required subject would elect it were the requirement removed. To the extent that this condition prevailed, any obtained differences would be apparent rather than real.
2. Whether the student had taken biological science in addition to physical science in high school did not appear to be reflected in the achievement in general botany of those students in the College of Agriculture and Forestry. Practically a significant difference was obtained for the students in the College of Science, Literature, and the Arts who had taken the physical sciences rather than either the biological sciences or the biological and physical sciences in high school. If it had been possible to secure a group without any previous preparation in science, data for this group might have given some indication as to whether previous preparation in any kind of science is significant.

3. Interest in a particular course apparently should be a factor in achievement. The difficulty lies in an objective measure of interest. If liking for a particular subject bears a relationship to interest, then there appeared to be some tendency for those students predominantly liking science to attain a superior achievement in botany.
4. There was some indication of a superiority of men over women in achievement in general botany.

The justification for incorporating the results reported here with those findings recorded in former chapters must rest not so much upon any clear-cut conclusions that may be drawn but rather upon the focusing of attention upon the learner. That there are innumerable factors in learning that demand evaluations should be evident. It should be borne in mind that both elementary and advanced courses exist for the student. In developing curricula, students' needs and interests should be obvious. Some evidence has been introduced that interest in science exists for large numbers of individuals. The development of any course, elementary or advanced, should take cognizance of these interests, vocational and other. Among the objectives of the elementary course in botany there might well be listed the determination of the means by which interest in science may be utilized and perpetuated.

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CHAPTER VI

GENERAL SUMMARY

This study has centered around an evaluation of the function of the course in General Botany in preparing students for the pursual of sequent courses in the College of Agriculture and Forestry. In the foregoing chapters there have been described the techniques employed and the findings, together with their significance in relation to the problem under investigation. A recapitulation of the more important data, subject to the limitations imposed by the conditions circumscribing the investigation, follows:

1. Botany has been considered a basic science in the curricula of the College of Agriculture and Forestry since its organization.
2. From a small beginning of seven and one-half quarter credits devoted to elementary botany, the number was gradually increased to twenty-four; then diminished to nine, the number required at present. The median number of quarter credits devoted to elementary botany in the College of Agriculture is twelve for the period 1870-1928.
3. The range in quarter credits of elementary botany required in the College of Forestry has been from nine to eighteen, with nine the median number, for the period 1903-1928. Nine quarter credits constitute the present requirement.
4. In courses of botany other than the elementary, there has been a reduction from a maximum of twenty-four quarter credits as a general requirement to none at present in the College of Agriculture. At the same time the number of elective credits has ranged from three to twenty-four. Since 1914 the specialization of the student has been the basis for election.
5. In courses of botany other than elementary, the required number of quarter credits in the College of Forestry has ranged from one and one-half (a general requirement at present) to thirty in certain specialized courses during the period 1919-1921. In elective courses the range has been from fifteen to forty-five, depending upon the specialization of the student.
6. There gradually developed two types of courses in elementary botany, one of which was apparently designed to have the primary function of a survey course, the other the additional function of a prerequisite. These courses finally emerged until at present one course exists, which as far as the organization of the curriculum indicates, is designed to have the twofold function—survey and preparatory.
7. Although accretion in content resulted with the increase of time devoted to elementary botany and, correspondingly, deletion with decrease of time,

the general nature of the content appears to have remained quite constant. Of the two types of elementary courses, the scope of the survey or short course was a general survey of the plant kingdom with emphasis upon the morphology of flowering plants and comparative morphology; that of the preparatory or long course was similar in nature but more comprehensive and detailed in treatment.

8. In the development of the curricula a multiplicity of courses has been added. With this expansion the required and elective advanced courses in botany have given way to more specialized courses in the College of Agriculture and Forestry.
9. All the sequent courses in the College of Agriculture and Forestry that were analyzed contain botanical constituents but in amounts varying quantitatively, and to a certain degree qualitatively. The range in the amount of time devoted to botanical phases is from 5 per cent to 100 per cent. The median amount of time is 69 per cent.
10. A portion of the content of the twenty-one sequent courses analyzed deals with ecology in seventeen of the courses; taxonomy of flowering plants in seventeen of the courses; morphology of flowering plants in fifteen of the courses; physiology in thirteen of the courses; genetics in nine of the courses; plant pathology in eight of the courses; histology in four of the courses; bacteriology in four of the courses; cytology in two of the courses; and mycology in one of the courses.
11. None of the twenty-one sequent courses analyzed deals with either comparative morphology or algology.
12. The botanical content of one sequent course is distributed among eight botanical categories; of three sequent courses among seven botanical categories; of four sequent courses among six botanical categories; of one sequent course among five botanical categories; of two sequent courses among four botanical categories; of four sequent courses among three botanical categories; of five sequent courses between two botanical categories; and one sequent course is encompassed in one botanical category.
13. The botanical content of the three courses analyzed in the Division of Plant Pathology and Botany is distributed among eight botanical categories: morphology of flowering plants, taxonomy of flowering plants, physiology, mycology, ecology, histology, bacteriology, and genetics in the order named.
14. The botanical content of the five courses analyzed in the Division of Horticulture is distributed among nine botanical categories: physiology, taxonomy of flowering plants, morphology of flowering plants, ecology, genetics, plant pathology, histology, bacteriology, and cytology in the order named.
15. The botanical content of four courses analyzed in the Division of Agronomy is distributed among seven botanical categories: morphology of flowering plants, ecology, taxonomy of flowering plants, physiology, genetics, plant pathology, and bacteriology in the order named.
16. The botanical content of the eight courses analyzed in the College of

- Forestry is distributed among five botanical categories: ecology, histology, taxonomy of flowering plants, morphology of flowering plants, and physiology in the order named.
17. A study of the elements in any given sequent course assigned to a particular botanical category reveals them to be largely specific in nature.
 18. Elementary Ecology, Elementary Plant Physiology, and Taxonomy of Flowering Plants are primarily concerned with the botanical categories with which they are, respectively, associated.
 19. When considered as an entity, General Botany 4-5-6 appears to be a well coordinated course; when considered as a course preparing the student for the pursual of the sequent courses analyzed, its limitations appear insurmountable.
 20. A comparison of the mean achievement score of students who had had General Botany 4-5-6 with that of students who had not had it in such courses as Farm Crops 1, Fruit Growing 6, and Vegetable Growing 32, revealed no significant differences. This is quite likely due to the fact that in these courses the students are taught the botany deemed necessary for the pursual of the course within the course itself.
 21. The instrument used for measuring permanence of learning in elementary botany was a botany test developed from previous final objective examinations in General Botany 4-5-6. The validity of this test based upon instructors' grades in General Botany 4-5-6 as a criterion was found to be $.87 \pm .02$. The reliability as determined by the "split" test method and estimated by the Spearman-Brown formula was $.93 \pm .01$.
 22. The median score on the botany test of 126 students entering the course in General Botany 4-5-6 was 5.5.
 23. The median score on the botany test of twenty-four students in the College of Agriculture and Forestry as determined by the results from the components of the test given at the time of completing each quarter's work in General Botany 4-5-6 was 205; three months after completing the course, the median score for this group was 110.5.
 24. The median score on the botany test for a group of twenty-nine students in the College of Agriculture and Forestry, fifteen months after completing General Botany 4-5-6, was 53; for a group of twenty-two students, twenty-seven months after completion of General Botany 4-5-6, the median score was 49.
 25. The mean score on the immediate recall test in General Botany 4-5-6 for a group of twenty-four students was 207.4; the mean score on the delayed recall test given three months after completing the course was 117.3. The loss in retention was 43.4 per cent.
 26. The mean score on the immediate recall test in General Botany 4-5 for a group of thirty-six students was 141.8; the mean score on the delayed recall test given six months after completing General Botany 4-5 was 74.1. The loss in retention was 47.8 per cent.
 27. The students who have the most botanical information (as measured by

the botany test) at the time of completing General Botany 4-5 or General Botany 4-5-6 are likely to retain not only absolutely more but relatively more of this information after the lapse of six or three months in time.

28. There is a qualitative difference in the nature of the botanical information retained. The order of loss in certain botanical categories from the greatest to the least is as follows:

1. Comparative morphology
2. Algology
3. Histology
4. Cytology
5. Mycology
6. Morphology of flowering plants
7. Physiology

The loss is greatest in those botanical categories that do not enter into the content of the sequent courses.

29. There appears to be some relation between the botanical information possessed by the student and his achievement in those sequent courses that are largely botanical in nature.
30. Where comparisons were possible there was found to be no significant difference between the achievement of those students who took botany as a required subject and that of those who took it as an elective.
31. Whether the student had taken biological science in addition to physical science in high school did not appear to be reflected in the achievement in General Botany 4-5 of those students in the College of Agriculture and Forestry. Practically a significant difference was obtained for the students in the College of Science, Literature, and the Arts, who had taken the physical sciences rather than either the biological sciences or the biological and physical sciences in high school.
32. There appears to be some tendency for those students predominantly liking science to attain a superior achievement in General Botany.
33. There is some indication of a superiority of men over women in achievement in General Botany.

Implications and Recommendations.—In conclusion it is essential to summarize certain implications of the findings and to make such recommendations as appear warranted. It is recognized that the study has been exploratory rather than exhaustive. This limitation is probably inherent in any curricular problem. Radical departures from any long established organization are not likely to be made until certain bases providing points of departure have been formulated. In this study an attempt has been made to evaluate conditions as they are, thereby providing points of departure for projected reorganization or reconstruction. Any recommendations proposed should be tested by a systematic

program of appraisal, which calls for measurement of results and comparisons of outcomes emanating from alternate procedures. The new must be evaluated in terms of the old. Modern content should be chosen in the light of modern conceptions of the aims of education; but to justify its supplanting the old, it must demonstrate outcomes that better realize the present aims than did the old.

The implications of the findings tend toward warranting the conclusion that the elementary course in botany has become greatly restricted with respect to its function as a prerequisite for the sequent courses in the College of Agriculture and Forestry. If this is true of the past, the possibilities of its functioning as a prerequisite in the future are likely to become further and further circumscribed as the number of advanced courses continues to increase and make new demands upon it. A partial recognition of the limitations of the course in elementary botany is manifest in the establishment of such elementary courses as Elementary Ecology, Elementary Plant Physiology, and Taxonomy of Flowering Plants. These courses are an attempt to provide a more systematic and detailed treatment, which the time now devoted to the elementary course makes it impossible to give.

From the analyses of the sequent courses and the elementary courses certain facts were established:

1. Most of these sequent courses are really new courses in botany, more specialized, adding large amounts of new material and supplementing the elementary among them.
2. Elementary botany represents certain accretions and deletions from time to time, but the primary forces in this determination have not been the needs of the sequent courses. In fact, the needs of the sequent courses have not been made known to the compilers of the elementary course. The primary concern has probably always been an organization contemplated to prepare prospective botanists.
3. The outstanding categories of emphasis in the sequent courses are ecology, taxonomy, physiology, and morphology of flowering plants.
4. Such categories as comparative morphology, algology, and mycology (except in the case of Plant Pathology 1), to which approximately 37.5 per cent of the content of General Botany 4-5-6 is devoted, apparently have no correlates in the sequent courses.

In addition, data resulting from the study on permanence of learning in botany imply that neither mastery nor any considerable knowledge of the facts are retained by the students.

In view of these deductions certain proposed departures from the established curriculum are presented. The first proposal is concerned with the fundamental desideratum of this study; viz., the prerequisite function of elementary botany for students in the College of Agriculture and Forestry; the second, with values in addition to that of preparation and not limited to any particular group of students.

The first proposal is that in lieu of General Botany 4-5-6, the students in the College of Agriculture and Forestry be permitted to substitute the three elementary courses: Elementary Ecology, Elementary Plant Physiology, and Taxonomy of Flowering Plants. The analyses of these courses revealed them to be largely concerned with ecology, physiology, and taxonomy, respectively. Morphology of flowering plants enters into each course forming what might be termed connective tissue. These four categories, it has been pointed out, enter most largely into the sequent courses. It appears quite probable that these three elementary courses would enhance the preparation of the student for his subsequent work. This alternate procedure is recommended for appraisal.

The second proposal is that advanced by Dr. Harris⁶ and consists of the following arrangement:

1. A four-hour survey course that is a lecture, textbook, demonstration, and class recitation course in the hands of the better instructors. This course is open to the following groups of students:
 - A. To all students in the University.
 - B. To those students in the University completing the requirement for ten credits in science, provided two of the elementary courses (three credits each) are completed in addition to the four-hour survey course.
 - C. To those students in the College of Science, Literature, and the Arts who may elect it but who have already completed their science requirement in some other science, i.e., zoology.
2. The election of two of the elementary courses—Elementary Ecology, Taxonomy of Flowering Plants, Elementary Plant Physiology, Elementary Algology, etc. By this election the ten credits in science would be attained. In order to be admitted into these courses the student must have a grade of C in the survey course.

Since this arrangement is provided for all the students of the University, the students in the College of Agriculture and Forestry would

⁶ Head of the Department of Botany, College of Science, Literature, and the Arts. This plan of reorganization was adopted at the beginning of the fall quarter of 1928-1929.

then take the four-hour survey course and elect two of the several elementary courses provided. For students entering forestry, the election of Elementary Ecology and Taxonomy of Flowering Plants would seem advisable; for students specializing in horticulture—Elementary Plant Physiology and Taxonomy of Flowering Plants; for students in agronomy—Elementary Ecology and Elementary Plant Physiology; and for students in plant pathology—perhaps Elementary Plant Physiology and Elementary Mycology. This plan of reorganization should merit appraisal.

Although this study has been primarily concerned with the evaluation of General Botany 4-5-6 from the standpoint of a prerequisite, there are certain implications arising that might warrant further consideration for the second proposal advanced above. From data previously presented in Chapter V, it is observed that 39.3 per cent of the individuals enrolled in courses in elementary botany attain a grade of *D* or below. Of those who complete these courses successfully, not a large percentage become botanists. It appears that these might be factors in determining the content of the survey course. It is suggested that the principal values that might accrue from a course of this nature would be largely appreciation and orientation. If these are desirable values, it would appear that the central theme might be built around the manifold contributions that botany has made to civilization and may make to an intelligent appreciation of one's environment, rather than be concerned with things of a too technical nature. The technical phases might be left largely to the specialized courses that are preparatory in function.

APPENDIX

FARM CROPS FINAL EXAMINATION

True or false answer: IF THE STATEMENT IS TRUE, MARK A CIRCLE AROUND THE NUMBER; IF FALSE, MARK AN X OPPOSITE THE NUMBER OF THE QUESTION.

1. The principal reason for cultivation of crops is to conserve moisture.
2. At least 10 tons of manure should be applied to soil annually.
3. Barley leaves are wider than oat leaves.
4. Marquillo is a leading variety of barley.
5. Minsturdi barley has a very stiff straw.
6. A grain of wheat is a seed.
7. The Colorado potato beetle is controlled by Bordeaux mixture spray.
8. White clover reproduces by runners.
9. The stems of Kentucky blue grass are flat.
10. Copper carbonate dust is used to control bunt or stinking smut of wheat.
11. Minnesota 23 is a leading oat variety.
12. Gehu is a leading dent corn variety.
13. Two-row barley has two kernels attached at each mesh.
14. Buckwheat is grown in Minnesota as a catch crop.
15. Wild oats in a sample of wheat lowers the numerical grade.
16. Grasses have alternate two-ranked leaves.
17. The leaf sheath is analogous to the petiole.
18. Stipules prevent water from entering the space between leaf sheath and stem.
19. All grasses have hollow stems.
20. Corn is naturally cross-fertilized.
21. The transfer of pollen from male to female flower is fertilization.
22. Ergot is a common disease of rye.
23. The higher the water content of seed, the greater its resistance to heat and cold.
24. An ear of corn high in moisture content is never suitable for seed.
25. Each kernel of pod corn is borne in an individual husk.
26. Alfalfa has parallel-veined leaves.
27. The sweet clover seed does not dehisce.
28. Manchu soy beans are adapted to Minnesota.
29. The sweet clover plant contains considerable sugar.
30. Covered smut destroys the entire oat panicle.

UNDERLINE THE ONE BEST ANSWER TO EACH IMPLIED QUESTION:

31. Corn smut may be controlled by: formaldehyde treatment, crop rotation, breeding.
32. Velvet barley is: hullless, beardless, smooth-awned.
33. The boll weevil attacks: stored grain, the cotton crop, tobacco.

34. Buckwheat is grown in Minnesota principally as: cash crop, regular rotation, catch crop.
35. Most of the wheat grown in the Red River Valley is: hard, red winter; soft, red winter; hard, red spring.
36. Peat soils are very high in: nitrogen, phosphorus, calcium.
37. Photosynthesis is: an energy storing process, an energy releasing process.
38. Flaxseed yields are often low because: flax is hard on land, weeds, flax wilt.
39. The sorghums are noted for: their cold resistance, high yields, drought resistance, disease resistance.
40. Corn for the silo should be cut in the: milk, glazed, mature stage.
41. Seed corn should be selected from well-matured ears: in the crib, at time of husking, from stalk before frost.
42. A winter-hardy variety of winter wheat is: Kanred, Minturki, Mindum.
43. Loose smut of oats can be controlled through use of: CuCO_3 dust, lime sulphur, formaldehyde.
44. Alfalfa sends up new growth from: rootstocks, crown, corms.
45. Red top is adapted to: dry soils, wet soils, shaded conditions.
46. Black stem rust is controlled by: spraying with formaldehyde, seed selection, breeding.
47. A farmer may expect: 1, 3, 5 cuttings of alfalfa per year.
48. The chinch bug attacks: timothy, corn, tobacco.
49. The principal wheat of Kansas is: hard, red winter; hard, red spring; soft, red winter.
50. Milo is a saccharine, non-saccharine sorghum.
51. Corn may be harvested most economically: by hogging-off, shelling, husking.
52. An average yield of oats per acre is: 35, 50, 80, 100 bushels.
53. Cotton is limited to the cotton belt because of: soil, temperature, moisture.
54. Greatest amount of stooling is shown by: winter wheat, spring wheat.
55. The oat hull makes up about: 30, 40, 60 per cent of the entire grain.

SUPPLY THE MISSING WORDS:

56. The parts of a corn leaf are _____, _____, _____.
57. A plant which starts growth in the late summer or fall, produces seed the next summer and dies is a or an _____.
58. Two annual grasses grown primarily for forage are _____, _____.
59. Quack grass reproduces by _____ and _____.
60. The bacteria from _____ may be used to inoculate _____.
61. The flowering arrangement of a plant is called the _____.
62. A spikelet consists of _____.
63. The oat awn is borne on the _____.
64. The genus of corn is _____, wheat _____, oats _____.
65. The grassflower has _____ stamens.
66. Botanically, a corn silk consists of _____ and _____.
67. The seed of _____ is heart-shaped and has a strong odor.
68. _____ and _____ are flint-corn varieties adapted to northern Minnesota.

69. The correct seeding rates per acre are: winter wheat, _____; spring wheat, _____.
70. The correct seeding rates are: oats, _____; barley, _____.
71. _____, a cross between _____ and _____, is a spring wheat highly resistant to black stem rust.
72. _____ oats are very early maturing, short-strawed, and well-suited to southern Minnesota.
73. _____ alfalfa, a variety of the _____ group, is adapted to Minnesota.
74. The work in crop improvement of the Minnesota stations may be summarized under three heads: _____; _____; _____.
75. Alfalfa hay should be cut at the _____ stage.
76. Foreign red clover seed is stained _____ when it is unadapted to this country.
77. A good crop rotation plan for Minnesota is _____, _____, _____.
78. The corn belt includes the states of _____, _____, _____.
79. The requirements for germination are _____, _____, _____.
80. Potato scab may be controlled by _____.
81. _____ group of millets is the principal one in the U. S.
82. The _____, an annual, carbonaceous plant, with a ray flower inflorescence is adapted to northeastern Minnesota.
83. A good crop of sugar beets may be expected to yield about _____ per cent sugar.
84. The length of life of sugar cane is _____, and the crop is propagated by _____.
85. The weight per bushel of oats is _____; wheat, _____; barley, _____.
86. The weight per bushel of brome grass is _____; alfalfa, _____; red clover, _____.
87. Corn is a native of _____. The potato is a native of _____.
88. Plant foods enter the plant through the _____ by the processes of _____ and _____.
89. Mixed types of corn are _____, _____, _____, _____, and _____.
90. Weeds are scattered by _____, _____, _____, _____, _____.
91. Seed that has descended from an individual plant or group of plants, has a definite performance record and has otherwise shown itself worthy of distribution is _____ seed.
92. Most of the feeding value of hay is in the _____.
93. The plumule develops into the _____.
94. The parts of a dicotyledonous seed are _____, _____, _____, _____, and _____.
95. A weed may be defined as _____.
96. A smooth, dented variety of yellow corn well-suited to central and southern Minnesota is _____.

97. The timothy plant is _____ pollinated.
98. Soft wheats are most suitable for _____.
99. Corn is checked in planting in order to _____.
100. A secondary cornstalk is called a _____.

HORTICULTURE 32 (VEGETABLE GROWING) FINAL EXAMINATION

True or false answer: IF THE STATEMENT IS TRUE, MARK A CIRCLE AROUND THE NUMBER; IF FALSE, MARK AN X OPPOSITE THE NUMBER OF THE QUESTION.

1. The trend of vegetable production in recent years has been toward truck crop and canning crop production.
2. The growing of a truck crop is confined to regions near large markets.
3. Crops for the cannery are usually grown under contract.
4. Most of our garden seeds are imported.
5. The greater part of our varieties of cabbage, carrots, cauliflower, spinach, lettuce, celery, and radish were developed in Europe.
6. Vegetable forcing has developed because of the desire of employers to utilize their labor the year round.
7. In planning the home garden, perennial crops and long season vegetables are planted at one side.
8. Manure is applied to the vegetable garden to alter the chemical composition of the soil rather than to improve its physical condition.
9. Succession cropping is the growing of two crops on the same piece of land simultaneously.
10. Intercropping is a better system of cropping than succession cropping because less hand labor is involved.
11. Applying stable manure to, and plowing, the home garden plot in the fall is more desirable than doing these operations in the spring in northern latitudes.
12. For onions, tomatoes, and all vine crops a heavy application of stable manure is desirable immediately before planting.
13. Larger and more economical yields have been obtained in various trials from 16 tons of manure supplemented with a high grade, mixed commercial fertilizer than from 32 tons of manure alone.
14. Soils differ but little in fertilizer requirements.
15. The chief value of green manures is to maintain the humus content of a soil.
16. Crop yields are wholly dependent upon the presence of the necessary elements in the soil.
17. A sandy soil is most suitable for the growing of crops where large yields are more important than earliness.
18. Sandy loam soils are better than sandy soils for truck gardening because they are more retentive of moisture.
19. Clay soils are chiefly used for the growing of crops for the cannery.
20. Packing a peat or muck soil and maintaining a high water table are practices recommended as preventives of frost injury.

21. Beans, tomatoes, and peppers are usually grown on muck soils.
22. Nitrates are especially important in the growing of leaf crops.
23. Phosphates promote vegetative growth and are readily lost from a soil by leaching.
24. Organic forms of nitrates are more valuable for early spring growth than inorganic forms.
25. The rate of application of fertilizers depends largely upon the crop to be grown.
26. For quantities greater than 1,000 pounds to the acre applying to the hill is the best method for cucumbers.
27. Heavier applications of commercial fertilizers should be made to sand soils which are lower in fertility than loam soils.
28. Growers should value fertilizers according to the price per ton and not according to analysis.
29. All vegetables are benefited by adding lime to the soil.
30. Lime improves the physical condition of a clay soil by correcting the acidity.
31. The vegetable-forcing industry has developed chiefly through the demand for fresh vegetables.
32. A sunken-pit hotbed is better than one on the surface because a constant temperature can be maintained by replacing the old manure with fresh manure.
33. Sowing seed in flats in a hotbed permits better control of damping off than sowing directly into hotbed.
34. Ventilation in a hotbed or cold frame is necessary only during warm weather.
35. Frequent light waterings are best for seedlings in a hotbed because by this method the surface of the soil is kept moist.
36. Most of our annual vegetables are native to the tropics.
37. Most fruiting vegetables can be hardened off to withstand light frosts.
38. Plants started in a greenhouse or hotbed are usually transplanted once or twice before setting them in the field.
39. Vegetable crops differ in their ability to withstand transplanting. This is due to the difference in size of plants.
40. The best method to harden off plants is to grow them in warm, moist conditions.
41. In planting stocky and hardy transplanted cabbage plants in the field, the soil should be shaken off the roots so that they can be planted with a dibble.
42. The main object of cultivation is to kill weeds.
43. When plants are small, cultivation should be shallow and become deeper as their root systems develop.
44. Growing disease-resistant varieties is the best method of overcoming soil diseases.
45. Crop rotation in the growing of vegetables aids in the control of insects and diseases.

46. Insects with biting mouth parts are best controlled by contact poisons.
47. Storage houses above ground are better than storage cellars because temperature and humidity can be controlled.
48. The effect of storage on the vegetable industry is to increase the prices paid to the producer since a glut on the market is prevented.
49. Vegetable crops which store large quantities of starch require a plentiful supply of available potash in the soil.
50. Fungicides should be applied before the appearance of the disease.
51. Beets, spinach, lettuce, and onions are less tolerant to acid soils than are potatoes, tomatoes, and beans.
52. The vegetable grower should grow his own vegetable seeds.
53. Most of the vegetable seed industry is located in the eastern part of the United States.
54. Pure seed for the variety of peas, beans, and tomatoes cannot be saved when more than one variety is grown adjacent to each other.
55. Corn, cucumbers, melons, and squash are normally cross-pollinated.
56. Cucumbers, muskmelons, watermelons, pumpkins, and Hubbard squash will not intercross.
57. Spinach and asparagus have the male and female flowers on separate plants.
58. Melons, squash, pumpkins, cucumbers, and corn have two types of flowers on the same plant.
59. Beets, carrots, parsnips, and onions are biennials.
60. Beets, carrots, parsnips, and onions are root crops.
61. Peas, beans, tomatoes, and potatoes are annuals.
62. Peas, beans, and tomatoes are edible fruits.
63. Cabbage, cauliflower, celery, and spinach are grown for their edible vegetative parts and not for their fruiting parts.
64. The growing of truck crops was unimportant until the development of the refrigerator car.
65. Onions require a warm, dry atmosphere for best storage.
66. Celery, lettuce, radish, and spinach do best in a cool season.
67. Beans, squash, tomatoes, and potatoes do best in a warm season.
68. Cabbage, cauliflower, parsnips, and beets are able to withstand light summer frosts.
69. Cauliflower is grown under a wide range of climatic conditions.
70. Bees are necessary in order to produce a crop of squash, cucumbers, melons, and pumpkins.
71. Transplanting plants makes them sturdier with better developed root systems; this tends to increase the yield of the crop.
72. All seeds gradually lose their vitality with the lapse of time.
73. The only practical method for determining the vitality of seed is to conduct actual germination tests.
74. The rate at which seeds lose their vitality depends upon the kind of seed and upon the conditions of storage.
75. Sweet corn, onions, carrots, and parsnip seeds retain their vitality longer than most seeds.

76. Squash, watermelon, muskmelon, and tomato seeds lose their vitality quicker than most seeds.
77. Cabbage and tomato plants are usually hardened off to withstand light frosts before transplanting into the field.
78. The time to plant a crop in the spring is based for the most part on the time the produce is desired.
79. "Damping off" of seedlings is caused by excessive moisture rather than by disease.
80. Vegetables are shipped in packages which have been standardized for each crop.
81. Market gardeners haul their products direct to market by wagon or motor truck, or ship relatively short distances by express or freight.
82. Asparagus, rhubarb, and horse-radish are native to the Old World and were imported into the United States during the early days of colonization.
83. Considerable asparagus is grown for canning purposes.
84. Asparagus is commercially propagated from cuttings.
85. Salt is essential to the growth of asparagus.
86. Asparagus requires the most cultural attention after the crop is harvested.
87. In order to secure a large cutting of asparagus, fertilizers should be applied early in the spring before growth starts.
88. In starting asparagus from seed this spring (1927), I will make my first full harvest the third year (1929).
89. Blanched asparagus is produced by use of certain varieties.
90. The best method for controlling asparagus rust is to cut off, remove, and burn all the tops in the fall.
91. Dusting and spraying are ineffective in the control of asparagus rust.
92. Rhubarb has large storage roots, while asparagus stores very little food in its roots.
93. Rhubarb is propagated both by seed and by division of roots.
94. Rhubarb is native to the tropics and is easily damaged by frosts.
95. The principal advantage of a botanical classification of crops is from the standpoint of disease and insect control.
96. The duration of an asparagus bed depends largely upon the space given the plants, which should be at least 4 feet by 18 inches.
97. Rhubarb is an important truck crop in the southern states.
98. Since asparagus requires a retentive soil to develop large yields, it is desirable to add stable manure to the asparagus bed every spring.
99. The most efficient way of controlling asparagus beetles during the cutting season is by spraying with arsenate of lead.
100. Globe artichoke which is grown for its tubers is produced principally in southern regions.
101. Spinach is one of the twenty major vegetable crops of the United States.
102. Spinach makes its best growth in the warm part of the growing season.
103. For potherbs or greens, nitrogen is the most important element to apply to mineral soils.

104. A good way of supplying nitrogen is to apply small quantities of nitrate of soda or ammonia sulphate as top-dressing a number of times throughout the growing season.
105. Spinach is one of the oldest of the cultivated vegetables.
106. Underline the three most important spinach groups: 1. Norfolk or Bloomsdale spinach; 2. Prickly-seeded spinach; 3. Round-leaved spinach; 4. Thick-leaved spinach.
107. It is preferable to cut spinach after a light rain or dew rather than at a time when the leaves may be slightly wilted.
108. New Zealand spinach tolerates more hot weather than common spinach.
109. Swiss chard is a foliage beet, grown for its broad and fleshy leaf stalks.
110. About 25 per cent of the spinach crop is grown for canning purposes.
111. Muck soils are well-adapted to the growing of salad crops.
112. Self-blanching types of celery are grown more extensively than the green varieties for winter storage.
113. Care should be exercised to keep celery under relatively cool conditions before transplanting to the field.
114. Hardened celery plants have considerable resistance towards frost.
115. The principal reason why early celery is blanched with paper or boards is to get it on the market earlier than would be possible if soil were banked against the stalks.
116. When young celery plants are checked, they are very apt to form a seed stalk prematurely.
117. Trench storage is better than cold storage for celery because it is cheaper.
118. Head lettuce is less sensitive to climatic conditions than leaf lettuce.
119. Our supply of winter lettuce is composed mostly of leaf lettuce.
120. Lettuce and celery are more free from serious diseases than most vegetable crops.
121. Cabbage is the most important of the so-called leaf or green crops.
122. Since cabbage requires a soil retentive of moisture, a clay loam is the most desirable type of soil for late as well as early cabbage.
123. Acid phosphate is the most desirable fertilizer material for late cabbage grown in a general farm rotation, when manure is used in the rotation.
124. More than one cutting is necessary in the harvesting of cauliflower and cabbage.
125. Club root of cabbage can be controlled by seed treatment.
126. The most effective way of controlling cabbage-seed diseases is by testing the seed a year in advance.
127. In growing cauliflower the grower's chief concern is to obtain good seed.
128. All cole crops are hardy and thrive best in cool weather.
129. All cole crops belong to the same genus, *Brassica*.
130. The best method for controlling cabbage maggots is to treat the soil surrounding the base of the plants with a solution of one part of corrosive sublimate to 1,000 parts of water.

131. On large acreages a planting machine should be employed in planting cabbage.
132. The best method of controlling cabbage yellows is to grow resistant varieties.
133. Cauliflower will not withstand as severe a frost as cabbage and will be more easily injured by warm weather.
134. Broccoli is a large-growing, long-season cauliflower.
135. Brussels sprouts requires a longer season and is much hardier than cauliflower.
136. Chinese cabbage will withstand warmer weather than ordinary cabbage.
137. Carrots mature more rapidly than do beets.
138. Parsnips are grown as an early spring or late fall crop.
139. Rutabagas require wider spacing and a longer season than do turnips.
140. The most practical way of controlling radish maggots is by rotation of crops.
141. Beets need not be thinned if the seeder is properly adjusted.
142. On muck soils, potash and phosphorous are the most important mineral elements to apply for onion production.
143. Thinning onions on muck soil is more important than on mineral soils because the onions grow more luxuriantly on muck.
144. The onion is one of the most ancient of our cultivated crops.
145. Onions are frequently grown continuously in the same soil. This is done to reduce the expense of weed control to a minimum.
146. The American type of onion is milder in flavor than Bermuda and Spanish onions.
147. Onion sets are produced by sowing the seed late in the growing season and thereby preventing the onion from securing its full development.
148. Onions are one of our most frost-resistant crops.
149. Set onions are produced by using certain varieties which develop only to set-onion size the first year grown from seed and produce bulbs the second year.
150. Top sets are produced from certain onion varieties which produce small bulbs in place of seed on the inflorescence.
151. The climatic requirements of peas and beans are very similar.
152. Beans and peas belong to the legume family of plants.
153. The southern states produce very little of the dry bean crop because the summers are too hot for the plant.
154. The tomato is native to tropical America.
155. The tomato cannot be "hardened off" to withstand light summer frosts.
156. The development of short-season varieties has extended its northern limits of growth.
157. Bean anthracnose is best controlled by disturbing the vines when they are moist.
158. Length of growing season determines the northern limit of tomato production.
159. The discovery of ethylene gas as a means of ripening tomatoes is the great-

- est single development that has occurred in the vegetable industry in the last ten years.
160. The vine crops are closely related botanically and have similar cultural requirements.
 161. The English type of cucumber will set fruit without pollination but most of the American types require either artificial or insect pollination in order to produce fruits.
 162. Small sweet pickles and the larger dill sizes are obtained by growing varieties of different sizes.
 163. Muskmelons are produced principally in the southern states.
 164. Muskmelons should not be grown adjacent to cucumbers as they are liable to cross with a resulting loss of quality to the muskmelon crop.
 165. Watermelons are native to tropical America, and their principal production is in the southern states.
 166. The regions of cucumber production are farther north than those of muskmelons and watermelons; this is probably because of the greater frost resistance of the cucumber.
 167. The different types of commercial winter squash (*Cucurbita maxima*) are selections from the original Hubbard squash.
 168. Summer squashes are botanically closely related to pumpkins with which they readily cross.
 169. The native home of the potato is in the tropics.
 170. Hot weather is detrimental to the potato crop.
 171. The potato is very easily injured by frost.
 172. The cultivated potato was imported into Europe from North America.
 173. A potato variety will "run out" and give poorer yields after twenty years of continuous vegetative propagation.
 174. Very few of our commercial potato varieties flower and set true seed.
 175. Most of our potato varieties were obtained through bud sports.
 176. The six most important potato varieties in Minnesota are Early Ohio, Green Mountain, Rural New Yorker, Irish Cobbler, Burbank Russet, and Triumph.
 177. The Green Mountain is the most prevalent variety of potatoes in the central and southern part of Minnesota.
 178. Late maturing potato varieties are usually planted as early in the spring as possible so as to give them a sufficient time to mature.
 179. In cutting potatoes for planting the number of eyes per piece is the most important consideration.
 180. Manure is applied to the vegetable garden to alter the chemical composition of the soil rather than to improve its physical condition.
 181. Intercropping is a better system of cropping than succession cropping because less hand labor is involved.
 182. Clay soils are chiefly used for the growing of crops for the cannery.
 183. Packing a peat or muck soil and maintaining a high water table are practices recommended as preventives of frost injury.
 184. Lime improves the physical condition of a clay soil by correcting the acidity.

185. A sunken pit hotbed is better than one on the surface because a constant temperature can be maintained by replacing the old manure with fresh manure.
186. Most fruiting vegetables can be hardened off to withstand light frosts.
187. The vegetable grower should grow his own vegetable seeds.
188. Pure seed for the variety cannot be saved from peas, beans, and tomatoes when more than one variety is grown adjacent to each other.
189. Cucumbers, muskmelons, watermelons, pumpkins, and Hubbard squash will not intercross.
190. Beets, carrots, parsnips, and onions are root crops.
191. Peas, beans, tomatoes, and potatoes are annuals.
192. Cabbage, cauliflower, celery, and spinach are grown for their edible, vegetative parts and not for their fruiting parts.
193. Onions require a warm atmosphere for best storage.
194. Cabbage and tomato plants are usually hardened off to withstand light frosts before transplanting into the field.
195. Vegetables are shipped in packages which have been standardized for each crop.
196. Dusting and spraying are ineffective in the control of asparagus rust.
197. The most effective way of controlling asparagus beetles during the cutting season is by spraying with arsenate of lead.
198. Globe artichoke, which is grown for its tubers, is produced principally in southern regions.
199. Since asparagus requires a retentive soil to develop large yields, it is desirable to add stable manure to the asparagus bed every summer.
200. Rhubarb is propagated both by seed and by division of roots.

FRUIT GROWING FINAL EXAMINATION

THE FOLLOWING STATEMENTS ARE EITHER RIGHT OR WRONG. MARK EACH STATEMENT IN THE MARGIN AT LEFT WITH A CROSS (+) IF RIGHT, AND A CIRCLE (O) IF WRONG. DO NOT GUESS.

1. The apple orchard area in the United States is being rapidly increased by heavy planting.
2. In view of heavy planting the fruit industry in America is in danger of being overdone.
3. Wind pollination is the rule with apples and plums.
4. Rain prevents pollination by washing pollen from stigmas.
5. Pollen tubes of the apple will grow more rapidly when varieties are crossed than when self-pollinated.
6. It usually requires three years in Minnesota to grow a well-branched apple tree from a piece of root graft.
7. The red raspberry is commonly propagated by suckers.
8. The black raspberry is commonly propagated by root cuttings.
9. Nurserymen commonly propagate the currant by mound layering.
10. The grape is commonly propagated by hardwood cuttings.

11. Thirty feet is a good planting distance for apples and plums.
12. Heavy pruning reduces the supply of carbohydrates in a tree and increases the relative amount of nitrates.
13. A tree in a vegetative condition is liberally supplied with both carbohydrates and nitrates.
14. A tree in a fruiting condition has a liberal supply of carbohydrates and an excess of nitrates.
15. Experiments in cultivated apple orchards on fairly good soil indicate that commercial fertilizers are not needed.
16. Minnesota sod orchards generally require feeding with a nitrogenous fertilizer.
17. The red raspberry usually responds profitably to heavy manuring or fertilization.
18. As a general rule vigorous wood growth and heavy fruit production go together.
19. Sun scald is found upon the north side of the tree.
20. Potash fertilizer colors fruits.
21. A red variety of apple becomes less highly colored if grafted upon a tree whose fruits are uncolored.
22. A tender variety is not made inherently hardier by grafting it upon a hardy variety.
23. The cankerworm is the cause of wormy apples.
24. Fire blight is a fungous disease.
25. Carbohydrates are absorbed in the soil solution by means of root hairs.
26. Three or four pounds of powdered arsenate of lead are used to 50 gallons of water for codling moth.
27. The curculio is a biting insect and is controlled by a poison spray.
28. The best spraying is done at a pressure of 50 to 75 lbs.
29. Mosaic, curly leaf, and anthracnose are serious diseases of the raspberry.
30. Nurserymen collect plum pits in the fall, carefully dry them, store them in a cool, dry place and plant in the spring.
31. Some of the reasons for using cover crops are to conserve plant food, collect winter moisture, and increase moisture-holding capacity of soil.
32. The fruit spur making less than $\frac{1}{4}$ inch of growth does not produce flower buds strong enough to set fruit.
33. The method used in producing new varieties of fruits at the Fruit Breeding Farm is grafting and budding.
34. In cross-breeding hardy fruits the pistil of a tender variety is placed upon the stigma of a hardy variety.
35. The brambles are propagated by shield or T budding.
36. In grafting, the cambium layer of the cion and stock should come together at least at one point.
37. Winter pruning stimulates wood growth and summer pruning induces fruit production.
38. Continued heavy pruning of a tree increases its size and vigor.
39. Heavy pruning of a young tree tends to early fruit production.

40. As the apple tree reaches maturity the pruning should be less severe.
41. When a large number of limbs are removed from an old, neglected tree, the deficiency should be made good by the application of nitrogenous fertilizers.
42. The open-center system of pruning the apple tree promotes strength of crotch.
43. In removing a branch the cut should be made an inch or more from the trunk.
44. The apple ordinarily bears fruit on the current season's growth.
45. The fruit of the grape is borne on the current season's growth.
46. Fruiting with the raspberry and blackberry is heaviest in two- and three-year-old wood.
47. Mixed buds are found on the apple and pear trees.
48. The plum has collateral buds.
49. The fire blight is controlled by spraying with Bordeaux.
50. The codling moth is controlled with a contact insecticide.
51. The first (and only) codling moth spray is applied before the eggs have hatched.
52. There is generally only one brood of codling moth in Minnesota.
53. The apple scab is controlled by a dormant spray.
54. The apple maggot is controlled by spraying when the blossoms are pink.
55. To be most effective, the spray for codling moth should be applied when the tree is in full bloom.
56. Planting distances for raspberries and currants are 3 feet by 3 feet.
57. In planting fruit trees the dirt should be filled in loosely to avoid injuring the roots.
58. Spray outfits are provided with agitators to keep the particles of spray materials in suspension.
59. Spray should be applied in mist-like form to cover completely the leaves and fruit.
60. The apple orcharding in Minnesota can be profitably expanded.
61. Winter injury to apple orchards in Minnesota is not as severe as in some regions where orcharding is more extensive.
62. Lack of bees in the plum orchard at blossoming time usually means a poor crop.
63. Apples should be planted at the rate of 160 trees per acre.
64. The planting distance for the strawberry is 4 feet by 4 feet.
65. Continuous heavy pruning reduces fruit bearing in apples.
66. Pruning is a dwarfing process.
67. Sun scald commonly occurs in early winter.
68. Early maturity in fall has no effect upon sun scald.
69. Sun scald may be prevented by shading the trunk.
70. Late growth encourages winter injury.
71. Top working a tender variety on a hardy trunk does not increase the hardiness of the tender variety but prevents trunk and crotch injury.
72. Apple spurs fruit annually.

73. The longest spurs are the most fruitful.
74. The raspberry fruits on one-year-old spurs.
75. The gooseberry fruits on two-year-old wood only.
76. Moderate pruning is recommended for grapes.
77. Cover crops delay maturity.
78. Budding is used more commonly than grafting in propagation of the plum.
79. Fall and spring pruning are alike in their effect on the tree.
80. Injury to an open-centered tree is more easily repaired than is injury to a central leader type.
81. The rate of wound healing is directly correlated with the vigor of the tree.
82. Fall planting of apple trees is not recommended in Minnesota.
83. In selecting orchard locations air drainage is more important than soil type.
84. A southern exposure is preferable for orchards in the far north.
85. Right angles are obtained in laying out orchards by using a 2-3-4 triangle.
86. Proximity to large bodies of water delays blossoming.
87. All buds on a grape cane are potentially able to produce fruiting shoots.
88. All one-year-old basal shoots should be removed from the currant to prevent crowding.
89. The strawberry should be planted so that the crown is covered.
90. Thinning of the younger growth is better than heading back in pruning a bearing apple tree.
91. Young, neglected apple trees may be renovated readily by pruning.
92. Hybrid plum varieties have been produced in Minnesota through selection of bud sports.
93. The Wealthy apple was grown from seed by Peter Gideon at Excelsior, Minn.
94. The Hibernial is one of the hardy varieties of apples imported from Russia.
95. The Patten Greening, although of only fair quality, is recommended for planting in Minnesota because it is hardy.
96. The Northwestern Greening is noted for its highly aromatic quality.
97. The Northwestern Greening and Duchess, hardy winter apples, are widely grown in Minnesota.
98. The McIntosh apple was grown from seed in eastern Canada.
99. The currant forms fruit buds in the spring.
100. Cultivation or field rotation are better control measures than spraying for some fruit insects.

FOLLOW INSTRUCTIONS IN THE FOLLOWING:

101. (6)* Underscore varieties recommended for general planting in Minnesota:
- | | |
|-----------------------|--------------|
| Malinda | Patten |
| Grimes Golden | Wealthy |
| Haralson | Ben Davis |
| Duchess | Winesap |
| Northwestern Greening | Northern Spy |

*The figures in this column indicate the number of points each answer receives.

102. (1) Underscore the element which the orchardist most frequently needs to supply to his orchard on account of its scarcity in the soil:
- | | |
|------------|-----------|
| carbon | magnesium |
| nitrogen | sulphur |
| potassium | calcium |
| phosphorus | |
103. (2) Underscore the commercial fertilizers which the orchardist most likely finds profitable to apply to his orchard under ordinary conditions:
- | | |
|-------------------|--------|
| nitrate of soda | gypsum |
| ammonium sulphate | lime |
| muriate of potash | |
104. (3) Underscore contact insecticides:
- | | |
|------------------|-------------------|
| Bordeaux mixture | nicotine sulphate |
| lime sulphur | Paris green |
| hellebore | oil emulsion |

COMPLETE THE FOLLOWING STATEMENTS:

105. (1) Apple orchards in Minnesota should be sprayed _____ times.
106. (1) _____ is the best season for grafting the apple.
107. (1) Budding is performed in the month of _____.
108. (1) Apple scab is controlled by spraying with _____.
109. (2) The best planting distance for the grape is _____.
110. (1) Using $2\frac{3}{4}$ inch apples, a basket may be faced with _____ circles of fruit.
111. (5) The leading apple-producing states are: 1. _____ 2. _____
3. _____ 4. _____ 5. _____.
112. (1) The best time to prune the grape is in the _____ season.
113. (1) The most important factor in developing resistance to winter injury is _____.
114. (1) The _____ system of grape pruning is recommended for hardy grapes in Minnesota.
115. (1) The best fruiting wood of the currant is not over _____ years old.
116. (1) In pruning a two-story leader type of apple tree, the leader and _____ scaffold branches are left the first year.
117. (2) The hardy apples which were grown from seed in the upper Mississippi valley are _____ and _____.
118. (1) The _____ apple, although hardy and usually showing an attractive blush, is not of good quality, and generally will not keep later than December.
119. (2) The _____ and _____ are striped or red apples of good quality.
120. (3) Of the apple varieties commonly grown in Minnesota, _____ and _____ are oblate, while _____ is nearly round.
121. (1) The best red raspberry to grow in Minnesota is the _____.
122. (1) The _____ grape is commonly grown in Minnesota because it is hardy.

123. (2) Spraying to be effective should be both _____ and _____.
124. (4) Bordeaux mixture is made by using _____ lbs. of _____ and _____ lbs. of _____ in 50 gallons of water.
125. (1) The lime-sulphur solution is used as a summer spray at the rate of _____ parts of liquid lime-sulphur to _____ parts of water.
126. (3) The leading grape-producing states are 1. _____ 2. _____ 3. _____.
127. (2) A good system of orchard management for apples combines a permanent sod with _____ and _____.
128. (1) A serious virus disease of raspberries is _____.
129. (1) Cutting out of affected parts is a method of control of _____ disease.
130. (1) Twig blight of the plum is one of the manifestations of _____ disease.
131. (1) Late applications of arsenate of lead are recommended for the control of apple _____.
132. (2) Common fungicides in use in Minnesota are _____ and _____.
133. (1) The best contact insecticide for summer use is _____.
134. (1) The most commonly used poison insecticide is _____ of _____.
135. (2) The two common carriers of nitrogen used when commercial fertilizers are applied to orchards are _____ and _____.
136. (2) The life of an apple tree may be divided into the _____ period and the _____ period.
137. (1) The effect of heading back is to _____ fruit-bud formation.
138. (1) Girdling in the early part of the growing season increases the supply of _____ above the girdle.
139. (1) The strawberry is propagated by means of _____.
140. (1) The _____ system of orchard planting is recommended for Minnesota.
141. (1) A tree is accurately centered in the hole by use of the _____.
142. (1) Apple roots are killed or badly injured when soil temperatures go below _____ degrees F.
143. (1) Of our common fruits, the _____ is self-sterile in Minnesota.
144. (1) Cedar rust is controlled by _____.
145. (5) Apple scab, codling moth, and apple maggot are controlled by sprays applied as follows: _____.
146. (2) Materials used to control the pests mentioned in question 145 are _____ and _____.
147. (2) The parts of the plant affected by apple scab are _____ and _____.

148. (2) Fruit buds of the plum are borne on _____ and _____.
149. (3) The three most serious fungous diseases of the apple in Minnesota are:
1. _____ 2. _____ 3. _____
150. (2) Good air drainage is essential because it tends to offset injuries from _____ and _____.

GENERAL BOTANY 4 FINAL EXAMINATION

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. The bark of a tree includes everything outside the cambium ring.
2. Cork is formed outside of the epidermis in woody plants.
3. In most herbaceous plants cork replaces the epidermis.
4. An important function of cork is checking water loss.
5. The cortex is relatively thicker in herbs than in woody plants.
6. The pith is relatively larger in herbs than in woody plants.
7. Herbs have relatively more xylem than have woody plants.
8. As seen in cross-section the medullary rays appear thicker in woody plants than in herbs.
9. There are three primordial meristems at the tip of the corn stem.
10. The procambium strand is a primary meristem.
11. The vascular bundle of corn has no cambium.
12. The cortex cells of corn are practically all thick walled.
13. The procambium strands of corn stem are arranged in a circle.
14. The corn bundle is composed mainly of secondary xylem and phloem.
15. The bundle sheath is composed of sclerenchyma in corn.
16. Increase in diameter in a dicot. stem is due largely to addition of new cells.
17. The ground tissue of corn stem consists largely of collenchyma.
18. Internodes of grasses are generally hollow.
19. In immature grasses the base of each internode is meristematic.
20. The grape tendril never originates in the axil of a leaf.
21. The grape tendril never bears leaves.
22. The plum thorn originates immediately below a leaf.
23. The rhizome of quack grass never stores food.
24. An important function of quack grass is propagation.
25. A rootstock is a modified root.
26. A tuber of potato has nodes and internodes.
27. A bulb stores most of its food in leaves, not in the stem.
28. In the corm, food is stored mostly in leaf-bases.
29. The strawberry runner originates from a root.
30. Epidermis is a permanent tissue.
31. Protoderm is a meristematic tissue.
32. Pith of the herbaceous stem is composed of parenchyma.
33. Tracheal vessels of corn bundle conduct sugar away from the leaf.
34. Spiral vessels conduct water away from the root.

35. Primary xylem originates from the cambium.
36. Primary phloem is nearer the epidermis than is secondary phloem.
37. In basswood primary xylem is near the central pith.
38. Linen is derived from the xylem fibers of flax.
39. Hemp cord is derived from the xylem fibers of the hemp plant.
40. Paper is manufactured from the wood fibers and other xylem elements of certain trees such as spruce and poplar.
41. Bast fibers are usually more flexible than xylem fibers.
42. The large light flakes of quarter-sawed oak are due to the medullary rays.
43. The phloem region of corn contains many bast fibers.
44. The phloem region of basswood contains numerous bast fibers.
45. An important function of medullary rays is to strengthen the stem.
46. Fiber cells in the phloem region conduct much sugar.
47. Medullary rays conduct liquids across the stem.
48. Tracheids with bordered pits are abundant in poplar wood.

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. The nucleus of a cell is composed of cytoplasm.
2. There is no large central vacuole in a meristem cell.
3. Chloroplasts are usually found in cork cells.
4. Most epiderm cells contain chloroplasts.
5. The protoplasm of a typical plant cell is composed of cellulose.
6. An important function of pith cells is storage of water.
7. Xylem is composed largely of thick-walled cells.
8. The bundle sheath of corn is part of the xylem.
9. The bundle sheath of corn is part of the phloem.
10. The principal function of xylem fiber is conduction of water.
11. Chloroplasts are found in the cotyledons of the bean seedling.
12. The stem of corn develops from the epicotyl.
13. The micropyle of a bean seed is the scar where the seed broke away from its stalk.
14. In the cell of Elodea the chloroplasts generally move in a clock-wise direction.
15. The typical Elodea leaf is only one cell thick.
16. Starch is stored in the bean embryo.
17. Protein is stored in the bean embryo.
18. Oil is stored in the corn embryo.
19. The endosperm of the bean seed is inside the cotyledon.
20. The direct method of cell division is known as mitosis.
21. Chromosomes are supposed to be the carriers of hereditary characters from cell to cell.
22. The nucleolus disappears during the prophase of mitosis.
23. Daughter chromosomes separate during the metaphase.
24. The cell plate is formed during the prophase.
25. The nuclear membrane is composed of chromatin.

26. The nucleolus reappears during the telophase of mitosis.
27. The spindle disappears during the telophase.
28. The nuclear membrane reappears during the anaphase.
29. Longitudinal splitting occurs before segmentation of spireme.
30. Chromosomes are composed of cytoplasm.
31. In finished lumber the "grain" is due to annual rings.
32. Most underground stems are specialized for propagation.
33. No stem growing above ground is specialized for propagation.
34. The permanent segment of the axis of a bud bears normal foliage leaves.
35. The meristematic segment of the axis of a bud ceases to elongate as soon as the bud scales drop off.
36. Bud scales are modified leaves.
37. The sumac has the indeterminate method of growth.
38. The elm has the indeterminate method of growth.
39. Bud scales do not originate at nodes as do ordinary leaves.
40. Annual rings of wood are rings of cambium.
41. Fascicular cambium lies between vascular bundles.
42. In herbs most of the water passes up the stem through the central pith.
43. The vascular bundle of corn is a "closed" bundle.
44. The vascular bundle in dicot. stems are "open" bundles.
45. The basswood is a woody monocot. stem.

SUPPLY THE PROPER WORDS IN THE FOLLOWING:

An elongated, horizontal underground stem is called a _____(1) or _____(2). The _____(3) is an example of this type. Two common functions of this type of stem are _____(4) and _____(5). An elongated horizontal stem growing along the surface of the ground and developing scale leaves at the nodes is called a _____(6). The principal function of this modified stem is _____(7). The _____(8) produces this type of stem. A portion of a rootstock, much thickened and with buds on the side, is commonly called a _____(9). The _____(10) illustrates this type of stem. A short, solid, vertical, enlarged underground stem with one or a few well-developed buds at the top is called a _____(11). The _____(12) is an example of this type of stem. A short, flattened, disk-like underground stem with numerous fleshy scales which store food is called a _____(13). The _____(14) illustrates this type.

In the resting nucleus there is a nuclear net of material known as _____(15) and along this net are numerous granules of a material called _____(16). In an early stage of nuclear division the net takes the form of a thickened, coiled thread called the _____(17) which later breaks up transversely into segments known as _____(18). Two cones of delicate fibers meeting at the equator of the nucleus form the _____(19). The two daughter cells are first separated by the _____(20) which splits, forming two membranes. Between these two membranes the daughter protoplasts secrete a material which forms the _____(21) of the cell wall.

A thin-walled tissue whose cells are not much longer than wide is called _____ (22). If it still has the ability to form new cells it is called _____ (23); if it has lost this ability it is said to be _____ (24). When cells become thickened at the angles only the tissue is called _____ (25). When the walls are much thickened throughout the tissue is called _____ (26). If such cells are very thick walled and very short they may be called _____ (27); if much elongated and having tapering ends they are called _____ (28). If this last type of cell occurs in the xylem region it is called a _____ (29) _____ (30); if it is found in the bark it is called a _____ (31) _____ (32).

Xylem cells which originate from the primary meristem are known as _____ (33) _____ (34), those originating from the cambium make up a tissue known as the _____ (35) _____ (36). Six important characteristics of the stems are (37):

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

SUPPLY THE PROPER WORDS IN THE FOLLOWING:

The outer covering of a grain of corn is the _____ (1) _____ (2). The seed of corn consists of three principal parts, the _____ (3), the _____ (4), and the _____ (5). The number of cotyledons in the corn embryo is _____ (6). That part of the embryo which lies immediately below the first node is known as the _____ (7) and below the latter an organ called the _____ (8) gives rise to the _____ (9) _____ (10) of the seedling. The bud of the embryo is known as the _____ (11) or _____ (12). In germination of corn seed the _____ (13) does not elongate materially and therefore the scutellum remains underground. Most of the food stored in the corn seed is stored in the region known as the _____ (14). The most abundant food in this region is in the form of _____ (15) which can be tested with _____ (16). A second food in the form of _____ (17) is found in this same general region but nearer the seed coats. This can be tested with _____ (18). Another food in the form of _____ (19) is found in this seed in an organ known as the _____ (20) or _____ (21).

A typical plant cell consists of a mass of living material known as a _____ (22) and is usually surrounded by a wall or _____ (23). Each typical cell has a denser portion of protoplasm known as the _____ (24). All living material outside this denser portion is known under the name of _____ (25). Many cells contain specialized living structures, green, white, red, brown, or yellow in color, known collectively as _____ (26). When green these are called _____ (27); when white

or colorless _____(28); and when red, brown, or yellow they are called _____(29). The central part of a typical cell is occupied by a _____(30) filled with _____(31) _____(32). The protoplasm of such a cell has two bounding membranes, the one within called the _____(33) _____(34), the one without called the _____(35) _____(36).

The outer layer of bark in an old basswood stem consists of a tissue known as _____(37), which originates from the _____(38) _____(39). The outer cortex of such a stem originates from the _____(40) _____(41) and is known as _____(42) cortex. The inner cortex of such a stem originates from the _____(43) _____(44) and is known as _____(45) cortex. This endodermis is the innermost layer of the _____(46) and originates from the _____(47) _____(48). In the inner bark are conducting regions known as _____(49) which carry _____(50) away from the _____(51). The most important conducting element here is known as the _____(52) _____(53). The layer of cells separating the bark from the wood is known as _____(54). The wood-region is composed principally of a tissue called _____(55). The conducting elements here carry _____(56) away from the _____(57). The xylem and phloem of a dicot. vascular bundle are separated from each other by the _____(58) _____(59). The xylem regions of neighboring vascular bundles are separated from each other by _____(60).

GENERAL BOTANY 5 FINAL EXAMINATION

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. Pollination is generally essential for seed production.
2. Fertilization in flowers consists in the transfer of pollen from the stamen to the stigma.
3. Fertilization is generally essential for seed production.
4. The union of the sperm nucleus with the egg nucleus in the flower is called pollination.
5. Most showy flowers are pollinated by insects.
6. Most of our forest trees are wind pollinated.
7. Most of our grasses are insect pollinated.
8. Fertilization in a flower affects the entire ovule as well as the egg cell.
9. Fertilization may affect the receptacle, causing it to enlarge.
10. Fertilization never affects stamens, petals, or sepals.
11. The production of stamens and pistils in separate flowers prevents self-pollination.
12. Maturing stamens and pistils at different times in a given flower is a device for attracting insects to the flower.
13. Curious floral structures of mints and orchids tend to insure cross-pollination.

14. The poplars and cottonwoods produce stamens and pistils on different trees.
15. Willows usually produce stamens and pistils on the same tree.
16. Pine trees never produce stamens and pistils on the same tree.
17. The oak tree produces stamens and pistils in different flowers on the same tree.
18. The lily produces stamens and pistils in the same flowers.
19. The stamens of a given flower of fireweed or willow-herb ripen and shed their pollen before the stigmas of that flower are mature or ready to receive it.
20. Flowers are never sterile to their own pollen.
21. Wind-pollinated flowers produce relatively less pollen than insect-pollinated ones.
22. The pollen of wind-pollinated flowers is usually dry and dust-like.
23. The flower of the plum is perigynous.
24. The flower of the plum has but a single carpel.
25. The flower of the plum has ten petals.
26. The fruit of the plum is called a pome.
27. The fleshy part of the plum fruit originates from the receptacle.
28. The stone or pit of the plum is the seed coat.
29. The pericarp of the plum is part fleshy and part stony.
30. The flower of the apple is hypogynous.
31. The ovary of the apple is inferior.
32. The fleshy, edible part of the apple fruit originates mostly from the ovary wall.
33. The core of the apple originates from the receptacle.
34. The flower of the apple has five carpels.
35. The flower of the apple has but five petals.
36. The fruit of the apple is called a drupe.
37. The fruit of the apple is covered with an epidermis.
38. In all the dicotyledons the seeds are produced inside of the wall.
39. Petals of the apple may be considered as modified leaves.
40. A carpel is not a modified leaf.

SUPPLY THE PROPER WORDS IN THE FOLLOWING:

The ovary of an epigynous flower is said to be _____(1); the ovary of a perigynous or an hypogynous flower is said to be _____(2). The fruit of the plum develops from (a or an) _____(3) ovary. The edible part of the plum originates from a layer of the _____(4) called the _____(5); while the stone or pit originates from a layer of the _____(6) called the _____(7). The plum represents a type of fruit known as a _____(8) or _____(9). In the strawberry the fleshy, edible part originates from the _____(10). A type of fruit like the ripened ovary of the strawberry is called an _____(11). The apple flower has a _____(12) ovary and the fleshy, edible part of the fruit originates almost entirely from the _____(13); the leathery core originates from the _____(14) and the seed originates from the _____(15).

When the plant builds up organic compounds from carbon dioxide and water the process is known as _____ (16). It takes place in living cells that contain _____ (17) and the energy required for the process is derived from the _____ (18). That starch formation depends upon _____ (19) in the leaf may be shown by selecting a leaf part of which is _____ (20) and part _____ (21). If such a leaf is exposed for several hours to the sunlight, is then killed with _____ (22), the _____ (23) removed by boiling in _____ (24) tests with _____ (25) show that starch is present in the part that contained _____ (26) and absent elsewhere. Besides the materials entering into starch three conditions necessary for its formation by a plant are _____ (27), _____ (28), and _____ (29).

A short, leafy axis whose leaves are modified for purposes connected with reproduction is called a _____ (30). If sepals, petals, and stamens are attached below the ovary, the ovary is said to be _____ (31), and the flower is said to be _____ (32). If the ovary is completely sunken into the receptacle and fused with it, the ovary is said to be _____ (33), and the flower is said to be _____ (34). If the receptacle is cup-shaped so that calyx, corolla, and stamens are attached around the ovary but free from it, the flower is said to be _____ (35).

Air enters the leaf through pores known as _____ (36); in cork-covered stems it enters through _____ (37). Air is conveyed through the stem largely through the _____ (38) _____ (39).

The ferments in plants that render insoluble substances soluble are called _____ (40). One of these converting starch into _____ (41) is called _____ (42), another changing fats into _____ (43) or _____ (44) is called _____ (45). Another changing cellulose into _____ (46) is called _____ (47).

A leaf with a single leaf blade is said to be _____ (48), one with two or more leaf blades is said to be _____ (49). Leaves may be specialized for storage as in _____ (50), or for propagation as in _____ (51) _____ (52). Some leaves are specialized for capturing insects as in _____ (53), while others like those of _____ (54) are specialized for absorption of moisture from the air. In _____ (55) the leaves are modified into spines while those of _____ (56) form tendrils for climbing.

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. Spirogyra is a blue-green algæ.
2. Spirogyra is a much-branched filament.
3. The gametes of Spirogyra are similar in size.
4. Œdogonium belongs to a group known as the green algæ.
5. The zygote of Œdogonium may give rise to four plants.
6. The zygote of Spirogyra may give rise to four new plants.
7. Vaucheria is an unbranched blue-green algæ.
8. Oscillatoria reproduces by isogametes.

9. Blue-green algæ are never sufficiently abundant in lakes or streams to be particularly objectionable.
10. Some thallophytes do not possess chlorophyl.
11. Blue-green algæ do not ordinarily contain chloroplasts.
12. Spirogyra does have a well-defined nucleus.
13. Heterocysts are found in all blue-green algæ.
14. Oscillatoria belongs to a group known as the green algæ.
15. Most species of green algæ have sexual reproduction.
16. Pleurococcus is a blue-green algæ.
17. The male gamete of *Œdogonium* is called a spore.
18. The female gamete of *Œdogonium* is called an oogonium.
19. *Vaucheria* is an example of a heterogamous plant.
20. The chloroplasts of *Spirogyra* are elliptical or spherical in form.
21. A spikelet of oats may contain as many as ten flowers.
22. The oat flower has no sepals.
23. There is a pair of empty glumes for every flower of the oat spikelet.
24. The fruit of the oat is called an achene.
25. The stamens and pistil occur in the same flower in the oat.
26. The ovary wall of the oat grain is formed by the lemma and the palea.
27. The spines of the barberry are modified leaves.
28. The principal function of bud scales is to keep the bud warm.
29. Winter buds are usually found on annual plants.
30. The method of growth in the sumac is said to be determinate.
31. The buds of practically all Minnesota trees and shrubs are provided with bud scales.
32. Light is absolutely essential for photosynthesis.
33. Respiration is a constructive process.
34. Carbon dioxide is used in respiration.
35. Oxygen is liberated as a result of photosynthesis.
36. Carbohydrates are broken down in the process of photosynthesis.
37. Respiration occurs in all living cells that are in the light.
38. Photosynthesis occurs in all living cells that are in the light.
39. Transpiration is an important factor in lifting water in plant stems.
40. The seeds are on the outside of the ovary wall in strawberry.
41. The strawberry is an aggregate fruit.
42. The flower of the strawberry is epigynous.
43. The strawberry has a compound pistil.
44. *Chlamydomonas* reproduces by isogametes.
45. *Pleurococcus* reproduces by heterogametes.
46. Green algae have well-defined nuclei, blue-green algae have not.
47. Blue-green algæ have definite chloroplasts, green algæ have not.

SUPPLY THE PROPER WORDS IN THE FOLLOWING:

The perfect flower has four sets of organs. The outermost of these is called the _____ (1), each unit of which is called a _____ (2). The next set is called the _____ (3), each unit of this being called a _____ (4). The individuals of the third set are called _____ (5). In the center of the flower we find one or more _____ (6). The stamen has two parts, the _____ (7) and the _____ (8). The function of the stamen is to produce the _____ (9). The pistil has three parts: the _____ (10), the _____ (11), and the _____ (12). The primary function of the pistil is to produce _____ (13).

In *Vaucheria* the _____ (14) escapes into the water, swims about for a time, settles down, and develops directly into a new plant. In *Ædogonium* the _____ (15) escapes from the _____ (16), fuses with the _____ (17), which is produced in an _____ (18). After fertilization, the _____ (19) germinates and produces _____ (20) and _____ (21), each of which may give rise to a new plant. In *Vaucheria* the name applied to the male gamete is _____ (22); to the male organ, _____ (23); to the female gamete is _____ (24), and to the female organ is _____ (25).

Chloroplasts are not ordinarily found in the _____ (26) algæ. In *Anabæna* and some other members of the group, special dead cells known as _____ (27) cause the filament to break up into segments, while other specialized resting cells known as _____ (28) or _____ (29) tide the plant over an unfavorable period and may later germinate and give rise to new plants or colonies.

If two gametes which fuse are essentially alike they are called _____ (30). A plant having gametes that differ much from each other is said to be _____ (31). A motile spore is called a _____ (32). A cell that must fuse with another before giving rise to a new plant is called a _____ (33). A cell that may give rise to another plant without fusion with another cell may be called a _____ (34) or _____ (35).

Photosynthesis and respiration are two processes taking place in all _____ (36) plants. _____ (37) occurs only in cells containing chlorophyll; _____ (38) occurs in all living cells. In the process of _____ (39) the materials used are carbon dioxide and _____ (40), and _____ (41) is given off as a waste product. In the process of _____ (42) oxygen is absorbed, while _____ (43) and _____ (44) are given off as waste products.

Enumerate five results of fertilization in a flower such as that of the apple (45):

1. _____
2. _____
3. _____
4. _____
5. _____

GENERAL BOTANY 6 FINAL EXAMINATION

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. All of the fungi are thallophytes.
2. None of the fungi have chlorophyll.
3. The sexual reproduction of *Rhizopus* (bread mold) is more like that of *Oedogonium* than it is like *Spirogyra*.
4. In the common moss the sex organs are borne on the under side of the gametophyte.
5. The sporophyte of the moss absorbs water through its roots.
6. The spore capsule of the moss contains numerous elaters.
7. The gametophyte of the moss bears leaves.
8. Stomata appear in the leaves of the moss plant.
9. Stomata appear in the sporophyte of the common moss.
10. The spores of the moss are non-motile.
11. The powdery mildew (*Microsphaera*) belongs to the Basidiomycetes.
12. *Riccia* belongs to the Ascomycetes.
13. The powdery mildew is a parasite.
14. The sporophyte of *Riccia* is a parasite.
15. The common moss is isogamous.
16. The fern is heterogamous.
17. One of the gametes in the bryophytes is always motile.
18. There is no chlorophyll in the sporophyte of the common moss.
19. The male and female organs in *Marchantia* are usually found on the same thallus.
20. The rhizoids of *Marchantia* are unicellular.
21. The rhizoids of the moss are multicellular.
22. The structure of the sporophyte of the common moss is not so complex as that of the sporophyte of *Marchantia*.
23. Some of the thallophytes produce true seeds.
24. A thallophyte must be either saprophytic or parasitic.
25. Some thallophytes possess chlorophyll.
26. *Selaginella* is the simplest plant that produces a true seed.
27. The seeds of the pine are not enclosed in an ovary wall.
28. All bacteria are harmful to man and should be destroyed.
29. Food is preserved by cold storage because the low temperature kills the bacteria in the food.
30. Most bacteria that cause contagious diseases are parasites.
31. The yeast plant is not a bacterium.
32. Yeast plants reproduce by a process called budding.
33. All bacteria multiply by simple division.
34. Some bacteria have sexual reproduction.
35. Some fungi produce plant diseases.
36. All plant diseases are caused by bacteria.

37. Bacteria are all unicellular.
38. Some species of bacteria contain chloroplasts.
39. Soil fertility may be materially increased by the activities of certain bacteria.
40. A ripe pine seed consists entirely of sporophytic material.
41. The pistil is the female gametophyte of the lily.
42. The pollen grain of the lily is a sperm cell.
43. The stamen is the male organ of the lily.
44. The gametophyte of the lily is called the flower.
45. The gametophyte of a moss plant is more highly developed than the gametophyte of a lily.

SUPPLY THE PROPER WORDS IN THE FOLLOWING:

When a moss spore germinates it produces a many-branched filament known as the _____(1). These filaments in the sunlight are _____(2) in color, underground they may be _____(3) or _____(4). After a time they may give rise to _____(5) which develop into leafy shoots. This generation of the moss is known as the _____(6). Male organs known as _____(7) produce gametes called _____(8). The female gamete or _____(9) is produced in an organ known as the _____(10). When the two gametes have fused, the _____(11) germinates giving rise to a _____(12) which when mature contains an absorbing organ called the _____(13) _____(14) which absorbs food from the _____(15). Above this absorbing organ is a stalk called the _____(16) and at the top of the latter is an organ called the _____(17) in which the _____(18) are borne. The sporophyte of the moss obtains its water from the _____(19), while the gametophyte obtains its water from the _____(20).

In *Selaginella*, the plant as we commonly see it is the _____(21) generation. It consists of three essential organs, the _____(22), the _____(23), and the _____(24). The carbohydrates used by this plant are manufactured by the _____(25); the water is obtained directly from the _____(26). When the end of a branch contains a compact cluster of spore-bearing leaves it is called a _____(27) or _____(28). The spores here are of two sizes, large and small. The large ones called _____(29) are produced; _____(number) (30) in each organ known as a _____(31). The leaf on which they are borne is called a _____(32). The small spores called _____(33) are formed, _____(34) (number) in each organ which is called a _____(35). When a large spore germinates it develops into a _____(36) _____(37), which, when mature produces reproductive cells known as _____(38). The _____(39) germinates, producing a small plant which, when mature forms sperms. When the gametes fuse, the _____(40) develops into a little plant of the _____(41) generation which is for a time completely embedded in the _____(42) _____(43). Later when its organs are well developed it becomes an independent plant and when mature produces

cells known as _____(44) and _____(45), which in turn start another generation.

Leaves occur in the _____(46) of the fern but not in the _____(47) generation. In *Selaginella* the leaves are found in _____(48) generation, in the angiosperms (lily, etc.) they appear in the _____(49) generation. Roots are found in the _____(50) generation of ferns, in the _____(51) generation of the pine, and in the _____(52) generation of the lily. Xylem and phloem occur in the _____(53) generation of the ferns and in the _____(54) generation of the seed plants. In *Riccia* the _____(55) generation is a parasite upon the _____(56). In pine the _____(57) generation is a parasite upon the _____(58).

In *Marchantia* the sporophyte consists of a _____(59) in which _____(60) are borne, a stalk called the _____(61) and an organ called the _____(62) _____(63) by means of which it absorbs its food from the _____(64). The gametophyte of this plant is formed by the germination of a _____(65).

IF IN THE FOLLOWING SENTENCES THE STATEMENT IS TRUE, DRAW A CIRCLE AROUND THE NUMBER; IF FALSE, CANCEL THE NUMBER WITH AN X. DO NOT GUESS.

1. The large fern plant as we commonly see it is the sporophyte.
2. The sporophyte of the fern has rhizoids for absorption of water.
3. Spores of the fern are borne in sporangia.
4. A single sporangium of the fern is called a sorus.
5. Sporangia of the fern are borne on the underside of the leaf.
6. Vegetative propagation in the common ferns occurs only in the sporophytic generation.
7. The principal function of the annulus in the fern sporangium is protection of the spores.
8. The mature sporophyte of the fern is dependent upon the gametophyte for its food supply.
9. The mature gametophyte of the fern is independent of sporophyte.
10. There are no stomata in the sporophyte of the fern.
11. There are no stomata in the gametophyte of the fern.
12. The sperms of the fern are motile.
13. The spores of the fern are provided with cilia for swimming.
14. Two spores of the fern may fuse and form a zygote.
15. Vegetative propagation in the fern occurs only in the sporophyte.
16. The egg cells of the fern are non-motile.
17. The female gamete of the fern is much larger than the sperms.
18. The sperm cell of the fern may germinate and give rise to a male gametophyte.
19. The gametophyte of the fern has true roots.
20. The sex organs of the fern are formed on the underside of the gametophyte.
21. The fern gametophyte is larger than that of *Marchantia*.
22. The sporophyte of the fern is larger than that of *Marchantia*.

23. The microsporangium of *Selaginella* is the male organ or antherid.
24. The megasporangium of *Selaginella* is an archegone.
25. The gametophyte of *Riccia* is larger than that of *Selaginella*.
26. All of the spores of a single megasporangium in *Selaginella* originate from a single spore mother cell.
27. The female gametophyte of a pine is smaller than that of a moss.
28. The male gametophyte of the lily is longer than that of pine.
29. The megaspore of the pine is never shed from the sporangium.
30. The whole pine tree is a gametophyte.
31. The mature sporophyte of the pine is called the embryo.
32. In ferns the chromosome number is reduced from the $2x$ to the x number during formation of spores from spore mother cell.
33. Each daughter nucleus of the first reduction division in the moss gives rise to two spores and only two.
34. During the process of spore formation from the spore mother cell, three spindles and only three are formed.
35. Uredospores of wheat rust will not germinate or develop on the wheat leaf.
36. Uredospores of wheat rust may germinate as soon as they are ripe.
37. Teleutospores germinate only upon the barberry leaf.
38. Teleutospores usually rest over winter before germinating.
39. Aecidiospores of wheat rust germinate only on the barberry leaf.
40. Wheat rust is a parasite.

(THE FOLLOWING STRUCTURES ARE FOUND IN THE PINE. INDICATE IN THE BLANKS FOLLOWING, THE STRUCTURES OF *SELAGINELLA* THAT CORRESPOND MORPHOLOGICALLY TO THESE. IN ANY CASE WHERE THERE IS NONE WRITE "NONE" IN THE BLANK.)

Endosperm _____(1). Nucellus _____(2). Pollen grain (mature) _____(3). Scale of pistillate cone _____(4). Scale of staminate cone _____(5). Young embryo sac _____(6). Young pollen grain _____(7). Pollen tube _____(8). Needle leaf _____(9). Entire pine tree _____(10). Pistillate cone _____(11). Staminate cone _____(12). Embryo of seed _____(13). Suspensor _____(14). Archegone _____(15). Prothallial cell of pollen grain _____(16). Integument _____(17). Young ovule _____(18). Root _____(19). Mature seed _____(20).

SUPPLY THE MISSING WORDS IN THE FOLLOWING:

In early summer the mycelium of wheat rust growing on the wheat plant forms rust-colored spores called _____(21). These germinate at once on the _____(22) plant and other similar spores may be formed. In late summer, however, a second form of spores appears on the same mycelium that produced the first form. This second form of spore known as a _____(23) rests over winter, germinating in the spring to form a _____(24) on which is born a third form of spores, the _____(25) which germinates on the

_____ (26) plant. When the mycelium on this last plant is mature it gives rise to spores called _____ (27) which will germinate on the _____ (28) plant. Here a mycelium is produced which in about two weeks gives rise to spores called _____ (29). The mycelium on _____ (30) then may arise from either of two forms of spores, the _____ (31) or the _____ (32). The mycelium on _____ (33) may give rise to two forms of functional spores, the _____ (34) or the _____ (35).

The fern plant as we commonly see it is the _____ (36) generation, the prothallium is the _____ (37) generation. The water used by the gametophyte is absorbed directly from the _____ (38) by organs called _____ (39). The carbohydrates used by the gametophyte are manufactured by chlorophyll of the _____ (40). The water used by the mature sporophyte of the fern is absorbed directly from the _____ (41) by organs called _____ (42). The carbohydrates used by this sporophyte are manufactured in an organ called the _____ (43). The sex organs of the fern, known as _____ (44) and _____ (45) are found on the _____ (46) (upper or lower) side of the _____ (47). The sporangia are produced in clusters known as _____ (48), on the _____ (49) (upper or lower) side of the _____ (50).

GENERAL BOTANY 4-5-6 TEST

Name _____ Class _____ College _____

Major _____ Graduate from what high school _____

General directions.—THE AIM OF THIS EXAMINATION IS TO GIVE YOU AN OPPORTUNITY TO SHOW WHAT YOU HAVE RETAINED FROM YOUR PREVIOUS CONTACT WITH BOTANY. READ THE DIRECTIONS FOR EACH PART CAREFULLY AND BE SURE YOU UNDERSTAND WHAT YOU ARE TO DO BEFORE YOU BEGIN.

UNDERLINE ANY OF THE FOLLOWING COURSES WHICH YOU HAVE TAKEN IN HIGH SCHOOL:

1. General science
2. Biology
3. Botany
4. Zoology
5. Physics
6. Chemistry
7. _____ (any other course in science)

UNDERLINE ANY OF THE FOLLOWING COURSES WHICH YOU HAVE TAKEN AT THE UNIVERSITY OF MINNESOTA:

1. General Botany 4f
2. General Botany 5w
3. General Botany 6s
4. Elementary Ecology

5. Elementary Plant Physiology
6. Taxonomy of Flowering Plants 9s
7. Forest Botany 3su
8. General Zoology 14f-15w-16s
9. General Forestry 1f
10. Field Dendrology 2su
11. Dendrology 3w or 4s
12. _____ (any other elementary course in botanical science)

GENERAL BOTANY 4-5-6 TRUE-FALSE TEST

Directions for true-false statements.—If in the following sentences the statement is true, draw a circle around the number; if false, cancel the number with an X. Do not guess.

1. The cell plate is formed during the prophase.
2. Most species of green algæ have sexual reproduction.
3. Yeast plants reproduce by a process called budding.
4. The basswood is a woody monocot. stem.
5. The pollen of wind-pollinated flowers is usually dry and dust-like.
6. The ovary of the apple is inferior.
7. The strawberry runner originates from a root.
8. The nucleolus reappears during the telophase of mitosis.
9. Uredospores of wheat rust will not germinate or develop on the wheat leaf.
10. No stem growing above ground is specialized for propagation.
11. The flower of the plum has ten petals.
12. The mature sporophyte of the fern is dependent upon the gametophyte for its food supply.
13. A tuber of potato has nodes and internodes.
14. Oscillatoria belong to a group known as the green algæ.
15. The mature sporophyte of the pine is called the embryo.
16. Vaucheria is an unbranched blue-green alga.
17. Petals of the apple may be considered as modified leaves.
18. The sperms of the fern are motile.
19. Bud scales are modified leaves.
20. The pericarp of the plum is part fleshy and part stony.
21. The structure of the sporophyte of the common moss is not so complex as that of the sporophyte of Marchantia.
22. Blue-green algæ do not ordinarily contain chloroplasts.
23. Maturing stamens and pistils at different times in a given flower is a device for attracting insects to the flower.
24. The female gametophyte of a pine is smaller than that of a moss.
25. The nucleus of a cell is composed of cytoplasm.
26. Pleurococcus reproduces by heterogametes.
27. The gametophyte of Riccia is larger than that of Selaginella
28. Bast fibers are usually more flexible than xylem fibers.

29. The union of the sperm nucleus with the egg nucleus in the flower is called pollination.
30. The megaspore of the pine is never shed from the sporangium.
31. The protoplasm of a typical plant cell is composed of cellulose.
32. The zygote of *Œdogonium* may give rise to four plants.
33. Curious floral structures of mints and orchids tend to insure cross pollination.
34. The stamens of a given flower of fireweed or willow-herb ripen and shed their pollen before the stigmas of that flower are mature or ready to receive it.
35. The powdery mildew (*Microsphæra*) belongs to the Basidiomycetes.
36. Teleutospores germinate only upon the barberry leaf.
37. The bark of a tree includes everything outside of the cambium ring.
38. The production of stamens and pistils in separate flowers prevents self-pollination.
39. *Chlamydomonas* reproduces by isogametes.
40. Epidermis is a permanent tissue.
41. The nuclear membrane reappears during the anaphase.
42. Some species of bacteria contain chloroplasts.
43. Internodes of grasses are generally hollow.
44. In all the dicotyledons the seeds are produced inside of the ovary wall.
45. Two spores of the fern may fuse and form a zygote.
46. *Riccia* belongs to the Ascomycetes.
47. Bacteria are all unicellular.
48. Vegetative propagation in the common ferns occurs only in the sporophytic generation.
49. The vascular bundles in dicot. stems are "open" bundles.
50. The fruit of the oat is called an achene.
51. Fertilization in flowers consists in the transfer of pollen from the stamen to the stigma.
52. The permanent segment of the axis of a bud bears normal foliage leaves.
53. The chloroplasts of *Spirogyra* are elliptical or spherical in form.
54. Each daughter nucleus of the first reduction division in the moss gives rise to two spores and only two.
55. The elm has the indeterminate method of growth.
56. Respiration occurs in all living cells that are in the light.
57. The oat flower has no sepals.
58. Daughter chromosomes separate during the metaphase.
59. The flower of the plum has but a single carpel.
60. The sexual reproduction of *Rhizopus* (bread mold) is more like that of *Œdogonium* than it is like *Spirogyra*.
61. The male gamete of *Œdogonium* is called a spore.
62. The fern is heterogamous.
63. The male gametophyte of the lily is longer than that of pine.
64. The ground tissue of corn stem consists largely of collenchyma.
65. The grape tendril never bears leaves.

66. An important function of pith cells is storage of water.
67. Protein is stored in the bean embryo.
68. The yeast plant is not a bacterium.
69. There are no stomata in the gametophyte of the fern.
70. There is a pair of empty glumes for every flower of the oat spikelet.
71. A thallophyte must be either saprophytic or parasitic.
72. The spores of the fern are provided with cilia for swimming.
73. The cortex is relatively thicker in herbs than in woody plants.
74. The direct method of cell division is known as mitosis.
75. The stone or pit of the plum is the seed coat.
76. The grape tendril never originates in the axil of a leaf.
77. The principal function of xylem fiber is conduction of water.
78. The principal function of the annulus in the fern sporangium is protection of the spores.
79. In immature grasses the base of each internode is meristematic.
80. Linen is derived from the xylem fibers of flax.
81. The female gamete of *Œdogonium* is called an oogonium.
82. Tracheids with bordered pits are abundant in poplar wood.
83. Stomata appear in the sporophyte of the common moss.
84. The spores of the moss are non-motile.
85. The cortex cells of corn are practically all thick-walled.
86. Willows usually produce stamens and pistils on the same tree.
87. The strawberry is an aggregate fruit.
88. Stomata appear in the leaves of the moss plant.
89. The stamen is the male organ of the lily.
90. The pollen grain of the lily is a sperm cell.
91. Chromosomes are supposed to be the carriers of hereditary characters from cell to cell.
92. The stem of corn develops from the epicotyl.
93. Annual rings of wood are rings of cambium.
94. The vascular bundle of corn is a "closed" bundle.
95. Bud scales do not originate at nodes as do ordinary leaves.
96. In finished lumber the "grain" is due to annual rings.
97. The rhizome of quack grass never stores food.
98. Medullary rays conduct liquids across the stem.
99. A bulb stores most of its food in leaves, not in stems.
100. Fiber cells in the phloem region conduct much sugar.
101. The plum thorn originates immediately below a leaf.
102. The stamens and pistils occur in the same flower in the oat.
103. The buds of practically all Minnesota trees and shrubs are provided with bud scales.
104. Light is absolutely essential for photosynthesis.
105. Oxygen is liberated as a result of photosynthesis.
106. Carbohydrates are broken down in the process of photosynthesis.
107. The seeds are on the outside of the ovary wall in strawberry.

108. The flower of the strawberry is epigynous.
109. The ovary wall of the oat grain is formed by the lemma and the palea.
110. Photosynthesis occurs in all living cells that are in the light.
111. Transpiration is an important factor in lifting water in plant stems.
112. Most of our forest trees are wind-pollinated.
113. Fertilization in a flower affects the entire ovule as well as the egg cell.
114. Flowers are never sterile to their own pollen.
115. The fruit of the plum is called a pome.
116. The powdery mildew is a parasite.
117. Some thallophytes possess chlorophyll.
118. All bacteria are harmful to man and should be destroyed.
119. Most bacteria that cause contagious diseases are parasites.
120. All plant diseases are caused by bacteria.
121. Soil fertility may be materially increased by the activities of certain bacteria.
122. Uredospores of wheat rust may germinate as soon as they are ripe.
123. Æcidiospores of wheat rust germinate only on the barberry leaf.
124. Wheat rust is a parasite.
125. Some of the thallophytes produce true seeds.
126. All of the fungi are thallophytes.

GENERAL BOTANY 4 COMPLETION TEST

Directions.—THE FOLLOWING QUESTIONS CAN BE ANSWERED BY A SINGLE WORD FOR EACH BLANK. SUPPLY THE PROPER WORD FOR EACH BLANK. YOUR SCORE WILL BE BASED ON THE NUMBER OF BLANK SPACES CORRECTLY FILLED. NO PENALTY WILL RESULT FROM BLANK SPACES INCORRECTLY FILLED.

An elongated horizontal underground stem is called a _____ (127) or _____ (128). The _____ (129) is an example of this type. Two common functions of this type of stem are _____ (130) and _____ (131). A short, solid, vertical, enlarged underground stem with one or a few well-developed buds at the top is called a _____ (132). The _____ (133) is an example of this type of stem. A short, flattened disk-like underground stem with numerous fleshy scales which store food is called a _____ (134). The _____ (135) illustrates this type.

In the resting nucleus there is a nuclear net of material known as _____ (136) and along this net are numerous granules of material called _____ (137). In an early stage of nuclear division the net takes the form of a thickened, coiled thread called the _____ (138) which later breaks up transversely into segments known as _____ (139). Two cones of delicate fibers meeting at the equator of the nucleus form the _____ (140). The two daughter cells are first separated by the _____ (141) which splits, forming two membranes. Between these two membranes the daughter photoplasts secrete a material which forms the _____ (142) _____ (143) of the cell wall.

A thin-walled tissue whose cells are not much longer than wide is called _____(144). If it still has the ability to form new cells it is called _____(145); if it has lost this ability it is said to be _____(146). When the cells become thickened at the angles only the tissue is called _____(147). When the walls are much thickened throughout, the tissue is called _____(148). If such cells are very thick-walled and very short they may be called _____(149); if much elongated and having tapering ends they are called _____(150). If this last type of cell occurs in the xylem region it is called a _____(151) _____(152); if it is found in the bark it is called a _____(153) _____(154).

Xylem cells which originate from the primary meristem are known as _____(155) _____(156); those originating from the cambium make up a tissue known as the _____(157) _____(158).

The outer covering of a grain of corn is the _____(159) _____(160). In germination of corn seed the _____(161) does not elongate materially and therefore the scutellum remains underground. Most of the food stored in the corn seed is stored in the region known as the _____(162). The most abundant food in this region is in the form of _____(163). A second food in the form of _____(164) is found in this same general region but nearer the seed coats. This can be tested with _____(165). Another food in the form of _____(166) is found in this seed in an organ known as the _____(167) or _____(168).

A typical plant cell consists of a mass of living material known as _____(169) and is usually surrounded by a wall of _____(170). Each typical cell has a denser portion of protoplasm known as the _____(171). All living material outside this denser portion is known under the name of _____(172). The central part of a typical cell is occupied by a _____(173) filled with _____(174) _____(175). The protoplasm of such a cell has two bounding membranes, the one within called the _____(176) _____(177); the one without called the _____(178) _____(179).

The outer layer of bark in an old basswood stem consists of a tissue known as _____(180), which originates from the _____(181). The outer cortex of such a stem originates from the _____(182) and is known as _____(183) cortex. The inner cortex of such a stem originates from the _____(184) _____(185) and is known as _____(186) cortex. The endodermis is the innermost layer of the _____(187) and originates from the _____(188) _____(189). The layer of cells separating the bark from the wood is known as _____(190). The wood-region is composed principally of a tissue called _____(191).

The xylem and phloem of a dicot. vascular bundle are separated from each other by the _____(192) _____(193). The xylem regions of neighboring vascular bundles are separated from each other by _____(194) _____(195).

GENERAL BOTANY 5 COMPLETION TEST

SUPPLY THE PROPER WORDS IN THE FOLLOWING BLANKS:

The perfect flower has four sets of organs. The outermost of these is called the _____(196), each unit of which is called a _____(197). The next set is called the _____(198). The primary function of the pistil is to produce _____(199).

In *Vaucheria* the _____(200) escapes with the water, swims about for a time, settles down and develops directly into a new plant. In *Vaucheria* the name applied to the male gamete is _____(201), to the male organ is _____(202), to the female gamete is _____(203), and to the female organ is _____(204). In *Oedogonium* after fertilization the _____(205) germinates and produces _____(206) _____(207) each of which may give rise to a new plant.

Chloroplasts are not ordinarily found in the _____(208) algæ. In *Anabaena* and some other members of the group, special dead cells known as _____(209), cause the filament to break up into segments, while other specialized resting cells known as _____(210) or _____(211) tide the plant over an unfavorable period.

A cell that must fuse with another before giving rise to a new plant is called a _____(212). A cell that may give rise to another plant without fusion with another cell may be called a _____(213) or _____(214).

In the process of _____(215) the materials used are carbon dioxide and _____(216), and _____(217) is given off as a waste product.

The fruit of the plum develops from (a or an) _____(218) ovary. The edible part of the plum originates from a layer of the _____(219) called the _____(220). The plum represents a type of fruit known as a _____(221) or _____(222). In the strawberry the fleshy, edible part originates from the _____(223). A type of fruit like the ripened ovary of the strawberry is called (a or an) _____(224). The apple flower has (a or an) _____(225) ovary and the fleshy, edible part of the fruit originates almost entirely from the _____(226); the leathery core originates from the _____(227); and the seed originates from the _____(228).

A short, leafy axis whose leaves are modified for purposes connected with reproduction is called a _____(229). If sepals, petals, and stamens are attached below the ovary, the ovary is said to be _____(230) and the flower is said to be _____(231).

Air enters the leaf through pores known as _____(232); in cork-covered stems it enters through _____(233). Air is conveyed through the stem largely through the _____(234) _____(235).

A leaf with two or more leaf blades is said to be _____(236). Leaves may be specialized for storage as in _____(237) or for propagation as in _____(238).

The ferments in plants that render insoluble substances soluble are called

_____ (239). One of these converting starch into _____ (240) is called _____ (241); another changing fats into _____ (242) or _____ (243) is called _____ (244). Another changing cellulose into _____ (245) is called _____ (246).

GENERAL BOTANY 6 COMPLETION TEST

SUPPLY THE PROPER WORDS IN THE FOLLOWING BLANKS:

When a moss spore germinates it produces a many-branched filament known as the _____ (247). These filaments in the sunlight are _____ (248) in color; underground they may be _____ (249) or _____ (250). After a time they may give rise to _____ (251) which develop into leafy shoots. This generation of the moss is known as the _____ (252). Male organs known as _____ (253) produce gametes called _____ (254). The female gamete or _____ (255) is produced in an organ known as the _____ (256).

When the end of a branch of the Selaginella contains a compact cluster of spore-bearing leaves it is called a _____ (257) or _____ (258). The spores here are of two sizes large and small. The large ones, called _____ (259), are produced _____ (260) (number) in each organ known as a _____ (261). The leaf on which they are borne is called a _____ (262). The small spores called _____ (263) are formed _____ (264) (number) in each organ which is called a _____ (265). When a large spore germinates it develops into a _____ (266), which when mature produces reproductive cells known as _____ (267). The _____ (268) germinates producing a small plant which when mature forms sperms. The sporophyte generation is for a time completely embedded in the _____ (269) _____ (270). Later when its organs are well developed it becomes an independent plant and when mature produces cells known as _____ (271) and _____ (272), which in turn start another generation.

In the pine the _____ (273) generation is a parasite upon the _____ (274).

THE FOLLOWING STRUCTURES ARE FOUND IN THE PINE. INDICATE IN THE BLANKS, FOLLOWING, THE STRUCTURES OF SELAGINELLA THAT CORRESPOND MORPHOLOGICALLY TO THESE. IN ANY CASE WHERE THERE IS NONE WRITE "NONE" IN THE BLANK.

Nucellus _____ (275)
 Pollen grain (mature) _____ (276)
 Young embryo sac _____ (277)
 Pollen tube _____ (278)
 Embryo of seed _____ (279)
 Prothallial cell of pollen grain _____ (280)
 Young ovule _____ (281)
 Mature seed _____ (282)

SUPPLY THE MISSING WORDS IN THE FOLLOWING BLANKS:

The mycelium of wheat rust grown on the wheat plant may arise from either of two forms of spores, the _____(283) or the _____(284). The mycelium on wheat may give rise to two forms of functional spores, the _____(285) and the _____(286).

The fern plant as we commonly see it is the _____(287) generation, the prothallium is the _____(288) generation. The water used by the gametophyte is absorbed directly from the _____(289) by organs called _____(290). The water used by the mature sporophyte of the fern is absorbed directly from the _____(291) by organs called _____(292). The sex organs of the fern known as _____(293) and _____(294) are found on the _____(295). The sporangia are produced in clusters known as _____(296), on the _____(297) (upper or lower) side of the _____(298).

KEY TO GENERAL BOTANY 4-5-6 TEST

NO. OF ITEM	CORRECT RESPONSE*	NO. OF ITEM	CORRECT RESPONSE	NO. OF ITEM	CORRECT RESPONSE
1	—	43	+	85	+
2	+	44	+	86	—
3	+	45	—	87	+
4	—	46	—	88	—
5	+	47	+	89	—
6	+	48	+	90	—
7	—	49	+	91	+
8	+	50	—	92	+
9	—	51	—	93	—
10	—	52	—	94	+
11	—	53	—	95	—
12	—	54	+	96	+
13	+	55	—	97	—
14	—	56	+	98	+
15	—	57	+	99	+
16	—	58	—	100	—
17	+	59	+	101	—
18	+	60	—	102	+
19	+	61	—	103	+
20	+	62	+	104	+
21	—	63	+	105	+
22	+	64	—	106	—
23	—	65	—	107	—
24	+	66	+	108	—
25	—	67	+	109	—
26	—	68	+	110	—
27	+	69	+	111	+
28	+	70	—	112	+
29	—	71	—	113	+
30	+	72	—	114	—
31	—	73	+	115	—
32	+	74	—	116	+
33	+	75	—	117	+
34	+	76	+	118	—
35	—	77	—	119	+
36	—	78	—	120	—
37	+	79	+	121	+
38	+	80	—	122	+
39	+	81	—	123	—
40	+	82	—	124	+
41	—	83	+	125	—
42	—	84	+	126	+

* If it is a true answer it is indicated by +; false by —.

NO. OF ITEM	CORRECT RESPONSE	NO. OF ITEM	CORRECT RESPONSE
127	Rhizome	170	Cellulose
128	Rootstock	171	Nucleus
129	Quack grass, etc.	172	Cytoplasm
130	Storage	173	Vacuole
131	Propagation	174	Cell
132	Corm	175	Sap
133	Gladiolus, etc.	176	Vacuolar
134	Bulb	177	Membrane
135	Onion, etc.	178	Plasma
136	Linin	179	Membrane
137	Chromatin	180	Cork or suberin
138	Spireme	181	Cork or phellogen cambium
139	Chromosomes	182	Cork or cambium
140	Spindle	183	Secondary
141	Cell plate	184	Ground
142	Middle	185	Meristem
143	Lamella	186	Primary
144	Parenchyma	187	Cortex
145	Meristem	188	Ground
146	Permanent	189	Meristem
147	Collenchyma	190	Cambium
148	Sclerenchyma	191	Xylem
149	Stone cells	192	Fascicular
150	Fibers	193	Cambium
151	Xylem	194	Medullary
152	Fiber	195	Rays
153	Bast	196	Calyx
154	Fiber	197	Sepal
155	Primary	198	Corolla
156	Xylem	199	Seeds
157	Secondary	200	Zoospore or Zoogonidium
158	Xylem	201	Sperm
159	Ovary	202	Antheridium
160	Wall	203	Egg
161	Hypocotyl	204	Oogonium
162	Endosperm	205	Zygote
163	Starch	206	Four
164	Protein	207	Zoospores
165	Millon's re-agent	208	Blue-green
166	Oil	209	Heterocysts
167	Scutellum	210	Spores
168	Cotyledon	211	Gonidia
169	Protoplasm	212	Gamete

NO. OF ITEM	CORRECT RESPONSE	NO. OF ITEM	CORRECT RESPONSE
213	Spore	256	Archegone
214	Gonidium	257	Cone
215	Photosynthesis	258	Strobilus
216	Water	259	Megaspores or macrospores
217	Oxygen	260	Four
218	Superior	261	Megasporangium
219	Ovary wall or pericarp	262	(Mega)-sporophyll
220	Epicarp	263	Microspores
221	Drupe	264	Many
222	Stone fruit	265	Microsporangium
223	Receptacle	266	Gametophyte (fem.)
224	Achene	267	Eggs
225	Inferior	268	Microspore
226	Receptacle	269	Female
227	Ovary wall or pericarp	270	Gametophyte
228	Ovule	271	Microspores
229	Flower	272	Megaspores
230	Superior	273	Sexual or gametophytic
231	Hypogynous	274	Sporophyte
232	Stomata	275	Megasporangium
233	Lenticels	276	Young male gametophyte
234	Intercellular	277	Megaspore
235	Spaces	278	Antheridium
236	Compound	279	Embryo sporophyte
237	Stone-crop, etc.	280	Prothallial cell of male
238	Bryophyllum or stone-crop, etc.	281	Megasporangium
239	Enzymes	282	Female gametophyte with embryo
240	Sugar	283	Uredospores
241	Diastase	284	Æcidiospores
242	Fatty acids	285	Uredospores
243	Glycerine	286	Teleutospores
244	Lipase	287	Sporophytic (asexual)
245	Sugar	288	Gametophytic (sexual)
246	Cytase	289	Soil
247	Protonema	290	Rhizoids
248	Green	291	Soil
249	Brown	292	Roots
250	Colorless	293	Antheridia
251	Buds	294	Archegonia
252	Gametophyte	295	Prothallium
253	Atheridia	296	Sori
254	Sperms	297	Lower
255	Egg	298	Leaf

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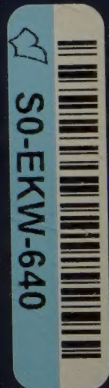
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